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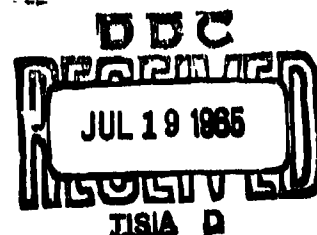
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ENVIRONMENTAL DESCRIPTIONS
OF RANGER TRAINING AREAS.

Part I. Mountain Training
Area, North Georgia.



The University of Tennessee
1 June 1963

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1 June 1963

Area Evaluation Section, Embankment and Foundation Branch
Soils Division
U. S. Army Engineer Waterways Experiment Station
Corps of Engineers
Vicksburg, Mississippi

Attention: Mr. Warren E. Grabau, Chief
Area Evaluation Section

Gentlemen:

In accordance with the terms of U. S. Army Contract No. DA-22-079-eng-333, dated May 15, 1962, it is a pleasure to submit this report, entitled "Environmental Descriptions of Ranger Training Areas. Part 1. Mountain Training Area, North Georgia."

Respectfully submitted,

E. Carl Shreve
Project Coordinator

Department of Civil Engineering
The University of Tennessee

ENVIRONMENTAL DESCRIPTIONS OF



TRAINING AREAS

Part 1. Mountain Training Area, North Georgia

Area Evaluation Section, Embankment and Foundation Branch,

Soils Division

U. S. Army Waterways Experiment Station, Corps of Engineers

Vicksburg, Mississippi

Contract No. DA-22-079-eng-333

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University of Tennessee

Knoxville, Tennessee

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ENVIRONMENTAL DESCRIPTIONS OF RANGER TRAINING AREAS.

I. MOUNTAIN TRAINING AREA, NORTH GEORGIA,

I. INTRODUCTION

A. Purpose and Scope of the Investigation

The present study is a part of the U. S. Army Research and Development Project MEGA (Military Evaluation of Geographic Areas) for which the administrative and technical services of the Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss., have been delegated investigative responsibility. As a phase of the project, a team composed of University of Tennessee personnel under the operational structure of the Engineering Experiment Station was given support for a study entitled, "Environmental Descriptions of Ranger Training Areas." Three Ranger training areas, at Fort Benning, Ga., Eglin Field, Florida, and northwest of Dahlonaga, Georgia, comprise the total area of study. The present report deals with the last named area which was selected for the initial investigation.

The primary objectives of this study are (1) to determine the magnitude and distribution of environmental factors which relate to the effectiveness of military operations, especially of the Ranger type, (2) to express these factors in terms of quantitative and semi-quantitative descriptive systems previously developed in other phases of the MEGA project, and (3) to develop or improve upon these and other systems

or collection techniques necessary to adequately catalogue and present pertinent and usable environmental data.

Five environmental components are herein considered: surface macrogeometry, surface microgeometry, surface composition, vegetation, and hydraulic geometry. The degree of emphasis placed on each of these components was determined by Waterways Experiment Station project supervisors. Particular consideration has been given macrogeometric terrain analysis and physiognomic description of vegetation, with resulting data plotted on areal maps on a scale of 1:25,000. Other environmental factors involving surface materials, hydrology, and microgeometry are also treated in this report to the extent that they could be adequately assessed within the time limitations imposed upon this phase of the project, and to the degree deemed relevant to the type of military operation involved.

B. Location

The Mountain Training Area of the U. S. Army Rangers is located in adjoining portions of southwest Fannin County, southwest Union County, and northwest Lumpkin County, in the Highland Section of north Georgia. (Figure 1). The area lies southeast of Blue Ridge, Fannin County, southwest of Blairsville, Union County, and northwest of Dahlonega, Lumpkin County, the latter serving as a useful reference point for locating purposes. The training area lies between longitudes $84^{\circ}01'47''$ W and $84^{\circ}10'24''$ W, and latitudes $30^{\circ}36'54''$ N and $30^{\circ}49'28''$ N, covering approximately 97 square miles within those boundaries.

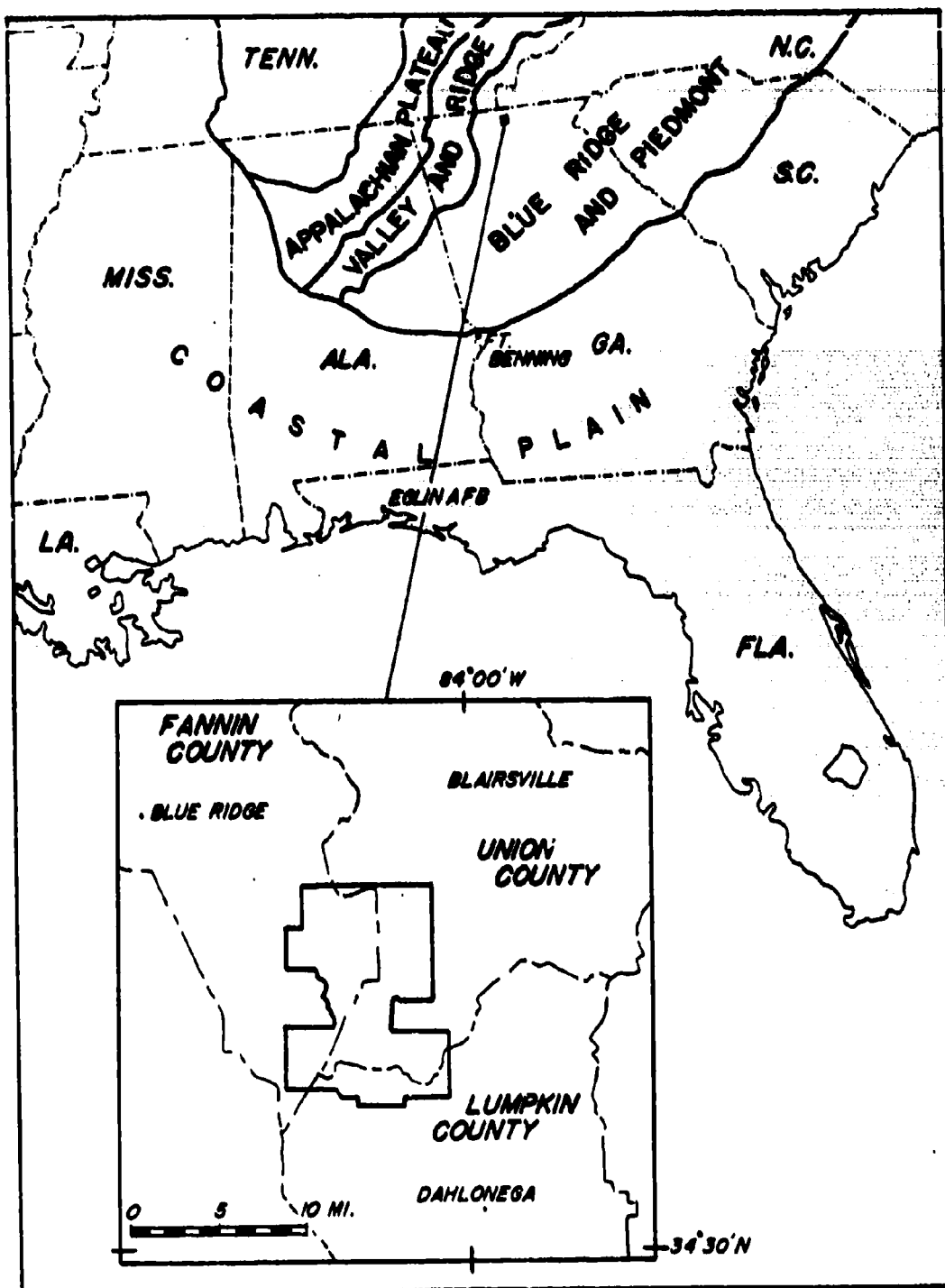


Figure 1. Regional setting and location of the Ranger Mountain Training area, North Georgia.

The area lies mainly within the Blue Ridge Province, with the inner edge of the Piedmont Province, in the form of the Dahlenega Plateau impinging from the south. The latter represents less than four square miles of the total area. The extreme southern portion of the area is a part of a belt several miles wide in which spurs of Highland mountains extend into the plateau-like Piedmont Province, and lobes of the latter penetrate the Blue Ridge highland. Thus, provincial boundaries are arbitrary in places.

Principal access to the area is provided by U. S. Highway 60 which crosses the central portion of the area by way of Wilscot Gap to the northwest and Woody Gap to the southeast. The area may be entered from the northeast on Mulky Gap Road which connects with U. S. Highway 76 west of Blairsville. U. S. Forest Service and logging roads within the area provide additional but often limited access to certain sections.

The area is included on portions of Army Map Service Series V845 topographic maps 4153 I SW (Wilscot), 4153 I SE (Mulky Gap), 4153 II NW (Ncontootla), 4153 II NE (Suches), and 4153 II SE (Campbell Mountain). On these maps, vertical (west to east) grid lines 58 to 73 and horizontal (south to north) grid lines 34 to 56 form extreme boundaries. These lines, subdivided into tenths, provide a useful coordinate system for locating data collection sites, and other points of reference.

C. Personnel

During the planning and early developmental stages of the project, Dr. Harry H. Ambrose, Department of Civil Engineering, and Dr. Royal E. Shanks, Department of Botany, served as project coordinator and supervising consultant, respectively. The untimely deaths of these men within a short space of time deprived the project of valuable contributions which would have been made to this study.

Professor E. Carl Shreve, Department of Civil Engineering, has served as project coordinator, and Dr. Fred H. Norris, Department of Botany, and Dr. R. E. McLaughlin, Department of Geology and Geography, have been supervising consultants.

Professor Dexter C. Jameson, Jr., Department of Civil Engineering, was supervisor of field and office work in connection with the project. Assisting in the collection of field data were Professor Franklin Robinson, Hiwassee College, and Mr. A. E. Coker, now with the Tennessee Division of Geology.

Mr. C. James Dunigan, Department of Geology and Geography, analyzed data and, with Professor Jameson, compiled the presentation on macrogeometry and contributed to the section on hydrology and hydraulic geometry. Professor Jameson supervised the cartography.

Dr. Norris and Professor Robinson compiled and analyzed the field and aerial photograph data on vegetation and constructed the vegetation map.

Dr. McLaughlin coordinated the physical sections of the study, developed the presentation on surface materials, and organized the report.

Mr. Thomas E. Young, Engineering Experiment Station, contributed his skills to the presentation of graphic material used in the report.

Mr. William A. Goodwin, now with the Highway Research Board, Washington, and Mr. E. A. Whitehurst and members of the Engineering Experiment Station staff provided technical and clerical services during the course of the investigation.

D. Acknowledgments

For cooperation, assistance, and many courtesies extended during various phases of this study, the investigating team is especially grateful to officers and men of the Ranger Department, United States Army Infantry: at Fort Benning, Colonel J. A. Meade, Jr., Lt. Col. John R. Fitzpatrick, Jr., and members of the administrative staff; at the mountain training camp, Lt. Col. M. R. Dame, Capt. Harry L. F. Ching, and members of the operational staff.

Drs. Peter A. Krenkel and Peter Hoadley, Vanderbilt University, gave freely of their time and patience in supplying the team with background information on macrogeometric measurement during informative briefing sessions in Knoxville and deserve special thanks. On another occasion, the team benefitted from exchange of ideas and experiences with Drs. Howard L. Mills and Sam Clagg of Marshall University.

Mr. John Allen and Mr. A. R. Bateson of the Division of Forest Management and Development, Tennessee Valley Authority, Norris, Tennessee, kindly made available stand location and data used in their 1958 forest inventory study of Fannin and Union Counties, Georgia.

For advice and guidance on numerous occasions both at Knoxville and in the study area, a great debt of gratitude is owed to Waterways Experiment Station personnel: Messrs. J. R. Compton, Warren E. Grabau, E. E. Garrett, E. E. Addor, and R. R. Friess. It is a particular pleasure to acknowledge the understanding and friendly spirit of cooperation exhibited by Mr. Garrett throughout the course of this investigation.

II. PHYSICAL DESCRIPTION OF THE MOUNTAIN TRAINING AREA

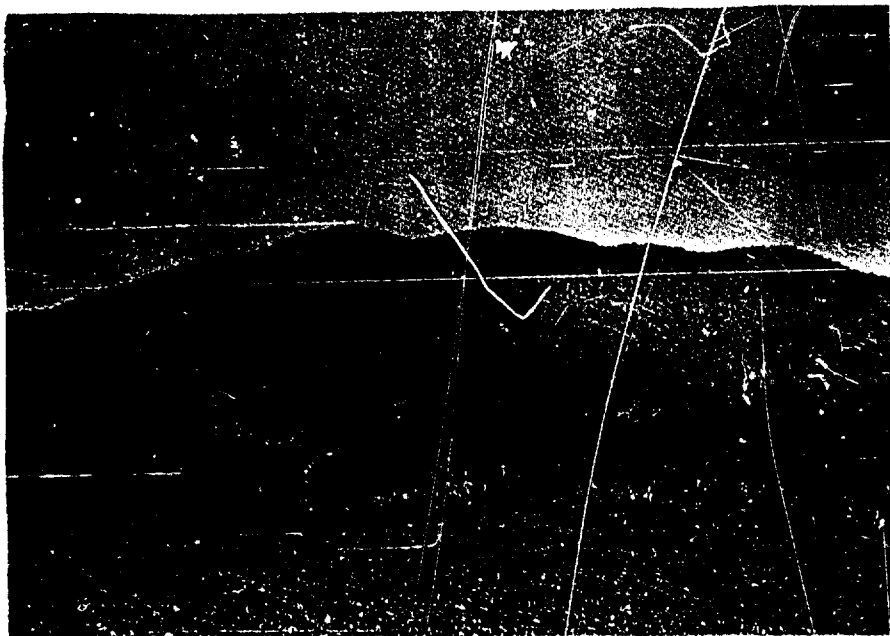
A. Topography

1. Physiographic Divisions

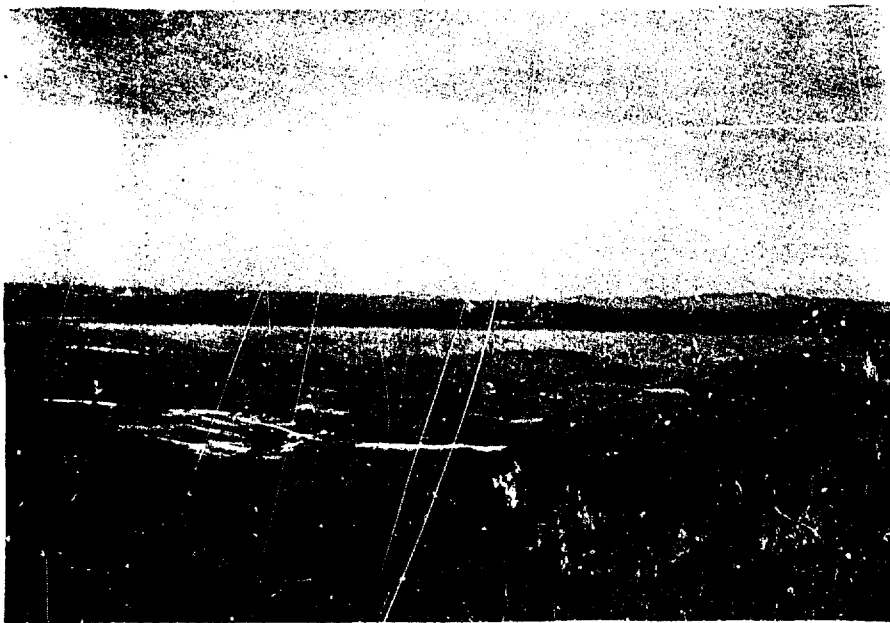
Topographically, the Ranger training area can be divided into the following physiographic divisions from south to north:

Southern Plateau Section. The inner edge of the Dahlenega sector of the Piedmont Plateau. An irregular bench or platform lying at the base of the Blue Ridge escarpment and interrupted by projecting spurs from it. (Figure 2 A). The plateau-like character is readily seen in panoramic view but hills and mountains rising above the general surface of 1600-1800 feet and valleys cut below it tend to obscure the fundamental pattern if viewed at close range (Figure 2 B). This division represents approximately 4% of the total area of study.

Southern Mountain Belt. The southernmost physiographic expression of the Blue Ridge Province in the study area. The belt terminates sharply southward with a high, steep, and sinuous escarpment with projecting spurs (Figure 3 A). Summits reach altitudes of 3000 feet or more along the crest which is broken by gaps developed 200 feet or more below the crest. The Tennessee Valley drainage divide is located along the escarpment. The high elevations of this section continue northward along the eastern and western



A

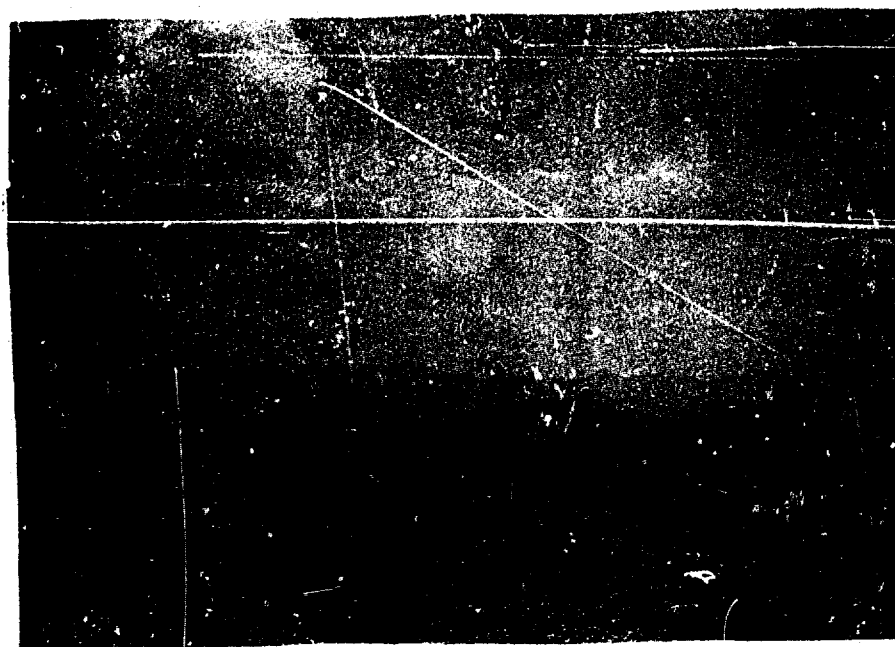


B

Figure 2. A. View from Ranger camp area toward Conner Mountain. B. Panoramic view toward Dahlonega. Plateau surface shown in the distance.



A



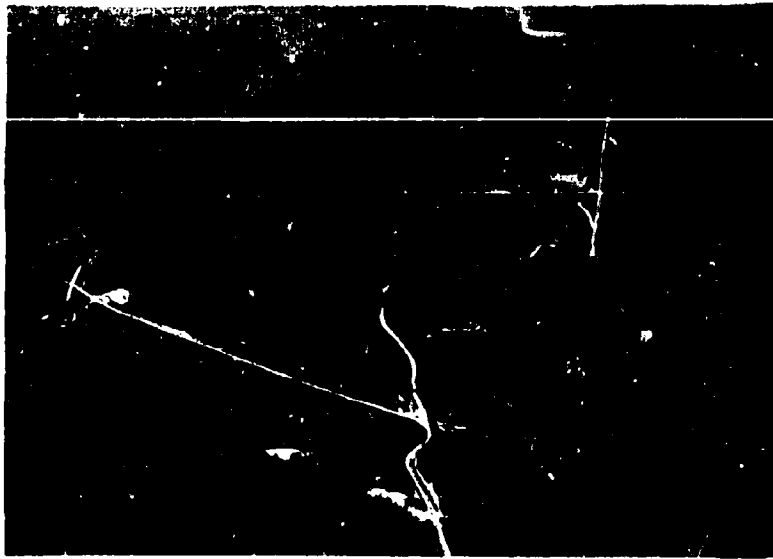
B

Figure 3. Southern Mountain Belt. A. View to east of Hawk Mountain along crest of the Blue Ridge. B. View toward the north from Hawk Mountain across Frozen Knob.

margins of the study area (Figure 3 B). A centrally located mountain mass extends about five miles northward from Copper Gap to maintain a drainage divide between Rock Creek and the upper Teccoa River watershed.

Intermontane Basin. Approximates the central to north-central section of the study area with a general elevation of 1800-1900 feet. The main arteries of the Teccoa River headwater drainage system converge more or less centripetally into the basin with valleys cut 200-400 feet below the general elevation (Figure 4 A). Headward tributary stream development has extended the perimeter of the basin into the flanking mountains, especially to the east, southeast, and southwest. Numerous monadnocks or inselbergs stand 500 feet to more than 2000 feet above the plateau-like general surface (Figure 4 B). The mountainous enclosure of the basin is breached in the northwestern part of the study area where the Skeenah Creek floodplain merges with the basin and the Teccoa River flows westward through a wide gap.

Northern Mountain Belt. The transverse ridge section north of the intermontane basin, extending from Wilscot Mountain across Duncan Ridge to Akin Mountain and Mulky Gap. With summits averaging more than 3400 feet in elevation, this belt forms a sinuous drainage divide with a north-facing slope terminated more or less abruptly at the southern



A



B

Figure 4. Intermontane Basin and Northern Mountain Belt. A. Cooper Creek - Toccoa River valley. Highway 60 (right) at junction with Mulky Gap road. B. View northwest toward Northern Mountain Belt. Monadnocks or inselbergs of the basin area in line of sight.

edge of the Nottely (Hiwassee) basin. The latter extends slightly into the study area northwest of Skeenah Gap where headwater tributaries of Skeenah and Young Cane creeks have narrowed the drainage divide to less than a half mile at one point. The relationship of the northern escarpment to the Nottely basin, which has a general plateau-like character with an average elevation of 2000 feet, is similar to the topographic distinctiveness of the southern mountain belt as it stands above the plateau section.

2. Relief Development and Trends

The genetic relationship of landforms within the study area was tested by comparing the elevations of 73 topographic highs with corresponding local relief measurements. A sample of 36 terrain units drawn from that portion of the area lying generally between horizontal grids 48 to 55 has an exceptionally high correlation of 71%. On the other hand, a sample of 37 units from the area approximately between grids 39 to 47 showed a less significant correlation of 31%. A regression equation showing the general relationship between local relief and elevation was fitted to the combined data of all 73 units (Figure 5). This suggests a physiographically distinct collection of related monadnocks or inselbergs.

Surfaces in the plateau and basin areas are gently rolling and the lower mountains exhibit subdued and characteristically rounded

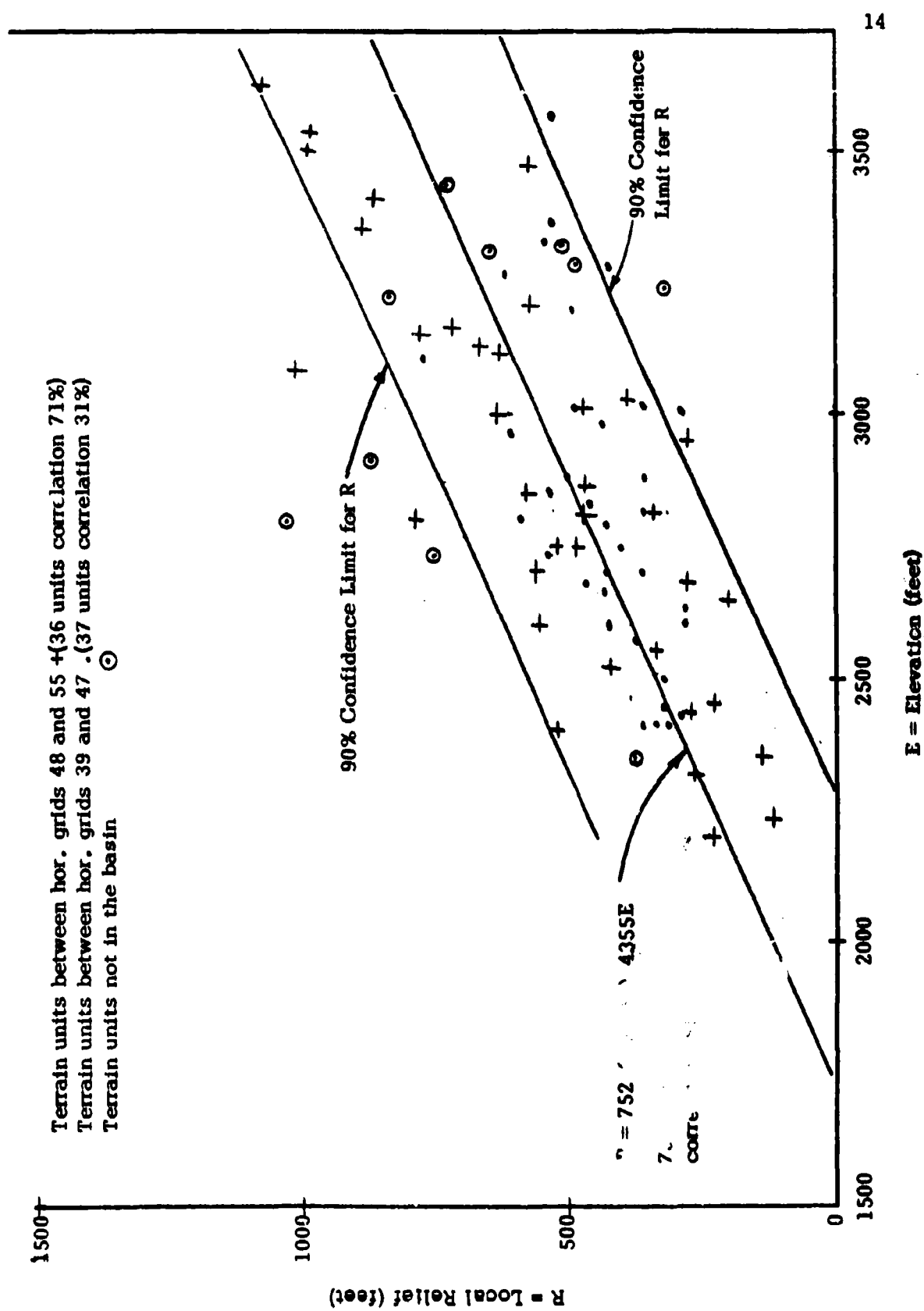


Figure 5. Regression of local relief R on the respective terrain unit highs, elevation E, for the basin in the U. S. Army Ranger training area northwest of Dahlonega, Georgia.

profiles. Steep slopes with rough surfaces are found in the higher mountain belts where linear ridges and spurs predominate. The crests of the ridges are commonly surmounted by rounded or angular knobs. Nearly nine per cent of the area lies above 3000 feet and less than four per cent below 1800 feet. Parke Knob, in the northern mountain belt, at 3622 feet is the highest point in the study area, and the lowest point, 1537 feet, is located on Ward Creek at the base of the southern escarpment. Thus, maximum relief is 2085 feet.

Old alluvium at various altitudes above the main drainage basin, coincidence of topographic levels (3500-, 3000-, and 2500-foot averages are striking), strath development and dissection, and the complexity of the multiple-ordered drainage pattern attest to cyclical geomorphic development of the area over a long period of time.

The physiographic divisions listed above trend in a roughly southwest-northeast direction. A similar alignment of fold axes, and, possibly, fault planes, and the development of particular rock types in somewhat parallel metamorphic zones may be related to the topographic pattern exhibited in the study area. Figure 6 shows the physiographic divisions roughly bounded by the 2500-foot contour line.

Keith (in LaForge, et al., 1923, p. 99) has noted that the mountains of the Highland Section of Georgia consist of two physiographic components, a southwest trending main axis (to which the name, "Blue Ridge," is commonly applied) and northwest trending extensions ("Cross Ranges"). The latter are separated by major river basins developed by parallel, northwest flowing streams. In this context, the southern

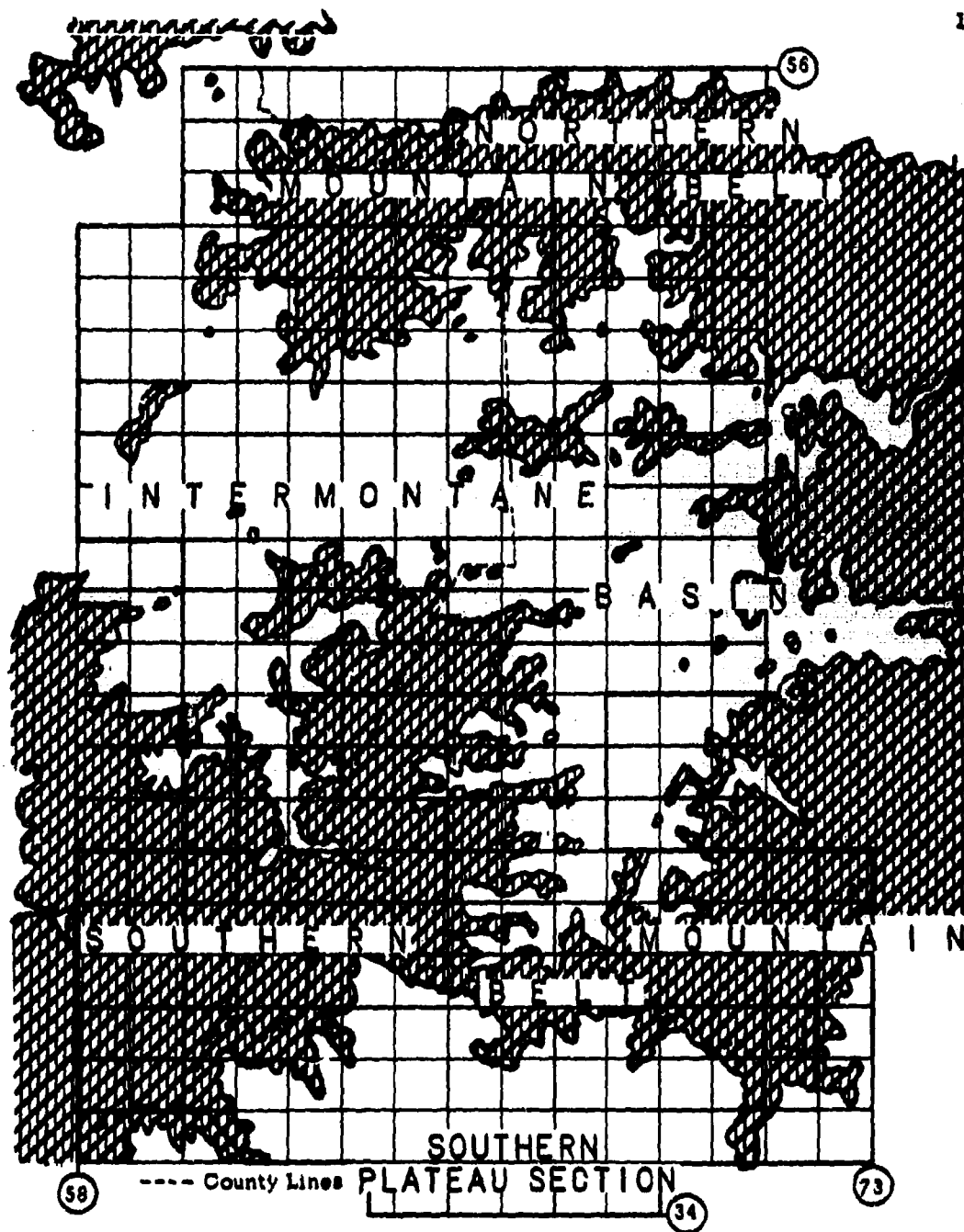


Figure 6. Physiographic divisions of the Ranger training area.

mountain belt of the study area would be part of the main axis, and the northern mountain belt part of a cross range.

B. Geology

1. General Considerations

The U. S. Geological Ellijay Folio compiled by LaForge and Phalen (1913) under the supervision of Arthur Keith contains the most detailed geologic information available on the study area. Despite the inadequate scale to which they are drawn, the general features of the area are delineated with considerable accuracy. The more recent U. S. G. S. Geologic Map of the U. S. (1932) with the Georgia crystalline rocks mostly mapped according to Jonas (1932), the Geologic Map of Georgia (1939) with the Blue Ridge-Piedmont rocks mapped by Crickmay, and the Geologic Map of North America (1946) show less detail or introduce questionable correlation. The supplemental description of the crystalline rocks by Crickmay (1952) refines the lithologic units employed in the Ellijay Folio by introducing metamorphic facies which are distributed in nearly parallel belts across the Upland section. Furcron (1953) has reexamined the stratigraphic and structural relationships of the rocks in the Ellijay quadrangle but the original interpretation by LaForge and Phalen is little challenged otherwise. Field observations made in connection with the present study are in similar accord.

The rocks of the Ranger training area, located in the southeastern portion of Ellijay quadrangle, are typical of the Georgia Highland and Central Upland sections (Figure 7.A) and correlative crystalline

belts elsewhere in the Blue Ridge and Piedmont provinces which are underlain by similar rocks and are physiographic divisions only. The complexity of the rocks is a reflection of the multiple origin, great age, and continuous involvement in the developmental history of the region. While none of these matters are of particular concern in the present study, the appraisal and classification of significant geologic features, such as the variety and nature of surface materials and their topographic expression, necessarily involves some consideration of genetic factors and fundamental characteristics.

2. Lithology and Petrology

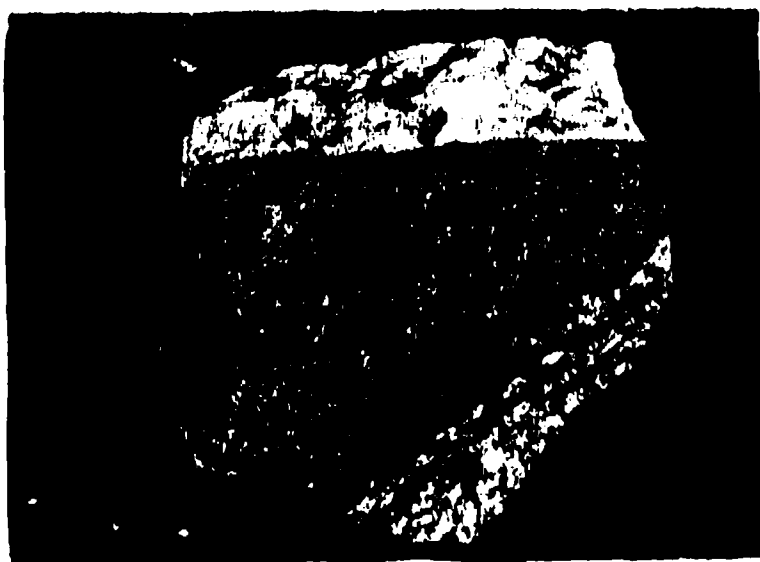
The rocks of the study area are contained mainly within the Amicalola belt of Crickmay (1932) (see Figure 7 B). This belt is made up largely of metamorphic rocks of the Carolina and Roan series as defined by Keith and mapped in the older folios. The gneiss and schist facies of the Carolina series constitute the dominant lithologies found in the study area and to a considerable degree determine the nature and extent of surface materials, and the distribution and geometry of landforms which characterize the area. Second in importance are rocks of the Roan series which are distributed in numerous sheets, stringers, and lenticular bodies, a few feet to several hundred yards in width and up to several miles in length. In the study area, linear bands of Roan rocks (see LaForge and Phalen, 1913, plate 2) sometimes branched and folded but with a generally southwest-northeast orientation, combine with facies of the Carolina series to provide many of the characteristic

geologic features peculiar to the southeastern half of the area, including all or portions of the southern plateau, southern mountain belt, and intermontane basin divisions established in a previous section of this report. The following description of the Carolina and Roan series as displayed in the study area is included as background and for later reference as the major considerations of this study are discussed.

Carolina series. Consists of two facies in the interpretation of Crickmay (1952): one dominated by gneiss, the other by schist, each containing the alternate rock type in subordinate amounts. The gneiss facies is characterized by equigranular biotite gneiss, fine to coarse-grained commonly in beds a few inches thick but grading into massive types. (Figure 8). The gneiss is frequently associated with layered mica schist and quartzite, usually massive. Quartz, feldspar (plagioclase and orthoclase), biotite (oriented and unoriented) and, to a lesser degree, muscovite mica are the typical minerals. Several accessory minerals often present; some, such as apatite, epidote, hornblende, and garnet are locally and often conspicuously abundant. The alternating dark (biotite) and light (quartz and feldspar) gneissic banding, in parallel, crumpled, and flow patterns affords ease in recognition. Interbeds of the associated strongly fissile mica schist are characterized by biotite and, along with the quartzite, form alternating sequences with the gneiss. This relationship reflects the sedimentary origin of these rocks. Apparent development of schistosity nearly parallel to initial bedding imparts a layered appearance to many of these rocks and results in the production of specific weathering characteristics (Figure 9). The rocks of this series occur throughout the study area, separately or associated with the Roan series. Mica and garnet-kyanite gneisses of the series dominate the northern mountain belt and the mountains forming the western enclosure of the intermontane basin and extending southwestward toward Springer Mountain near the southwestern corner of the study area. Representative rocks of the schist facies of the Carolina series are contained in a belt several miles wide, extending from the basin of Cooper Creek in the Yellow Mountain section in the northeastern part of the area, passing through the upper Toccoa basin in the vicinity of Gaddistown, and continuing toward Hightower and Winding Stair gaps on the southwest. Although interbeds of fine-grained biotite gneiss occur, the dominant lithologies are muscovite mica, quartz, garnet, and kyanite-

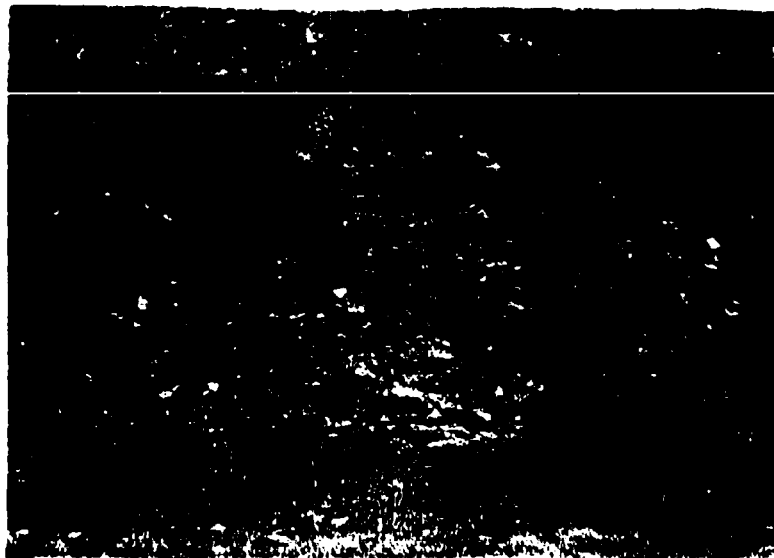


A



B

Figure 8. Gneissic rocks of the Ranger area. A. Quarry exposure .5 mile west of Cooper Gap. B. Specimen of biotite gneiss injected by quartz.



A



B

Figure 9. Schistose rocks of the Ranger area. A. Schist cut by dike near Margret. B. Chevron folding in schist near Cavender bridge.

graphite schists, ranging in color from dark to brownish yellow, depending on relative amounts of graphite present. Muscovite-kyanite schist, grading to gneiss and containing garnet in places, is abundant in the Duncan Ridge-Licking Mountain section of the northern mountain belt.

Roan series. Primarily a coarse-grained hornblende gneiss with gradations to hornblende schist and schistose diorite, often with inclusions of Carolina series rocks, the Roan having been emplaced into the older Carolina rocks as intrusive sills, dikes, and stocks prior to or contemporaneously with metamorphism (Keith, 1907, p. 3, LaFerge and Phalen, 1913, p. 4, Crickmay, 1932, pp. 34-37). Hornblende and layered quartz and feldspar (plagioclase) are the principal minerals but epidote, chlorite, biotite, garnet, apatite, and other accessory minerals occur in variable amounts. Metamorphism has resulted in textural changes rather than mineralogic alteration and the igneous origin of these rocks seems well established. The Roan rocks are generally conformable to the surrounding Carolina schists and gneisses with which they are associated in the banded manner described above. Soil development and topographic expression in areas underlain by rocks of this series are often recognizable and definitive.

In addition to the rocks of the Roan and Carolina series, numerous igneous intrusives are exposed on the surface at various places in the study area, and locally produce variations in the general pattern. The more important of these are listed as follows:

1. Especially in the southern mountain belt and particularly along the crest of the escarpment, pegmatite dikes from a foot to 500 feet in width have been injected mainly into the Carolina gneiss and schist, less frequently in other rock types (Figure 10 A). Feldspar, coarse-grained quartz, and muscovite mica (biotite locally) are the principal minerals. The strike of these dikes, which are conformable with the country rock, trends prevailingly to the northeast with dips ranging from 40° to 75° in a southeast direction (Furber and Teague (1943, p. 5).
2. Intruding areas of the Roan gneiss parallel to foliation are lenticular bodies a few hundred feet across and less than a half mile in length composed of ultramafic rocks containing serpentine, olivine, and pyroxene, with magnetite or biotite sometimes present. One such



A



B

Figure 10. Intrusive rocks of the Ranger area. A. Pegmatite dike south of Ward Creek. B. Granite gneiss near Frick Creek on Three Forks - Winding Stair Gap road.

zone extends from Sarah in the southeastern portion of the study area down the valley of Cane Creek south of Cane Creek Gap near the southeast border of the area. Other occurrences have been reported from south of Cooper Gap and along the south-projecting spur of Long Mountain (LaForge and Phalen, 1913, p. 5).

3. Intruding large areas of both Carolina and Roan gneisses, wholly engulfing or replacing them in places, are granitic plutons. In the study area, a strongly gneissic, biotite granite (Lithonia-type of Crickmay, 1952, p. 42) gneiss is found exposed particularly in the higher mountain masses (Figure 10 B).
4. Another granite biotite gneiss characterized by extreme distortion of biotite-rich and quartz-feldspar-rich bands is occasionally found intruding the gneiss facies of the Carolina series. This may be the type referred to as injection gneiss by Crickmay (1952, p. 45) and others.

The rocks of the study area are among the most complex to be found anywhere. They have undergone many changes in form and position, having been folded, faulted, crushed, and greatly metamorphosed. Mechanical deformation, chemical reconstitution, molecular exchange, and petrofabric alterations of one kind or another accompanying such changes have led to increased susceptibility to agents of weathering. Over a large portion of the area, therefore, deep weathering has reduced the original rocks to remnants and structureless masses.

3. Weathering

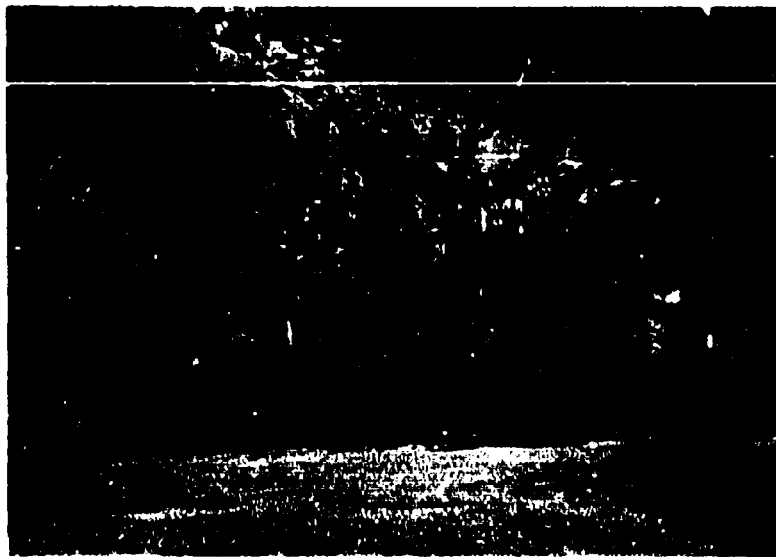
In an area with an average annual temperature between 50 degrees and 60 degrees and a minimum of 60 inches of rainfall annually, a condition which is likely to have obtained for a considerable length of time, the rocks of the study area reflect a long history of exposure to chemical weathering or decomposition. The stresses and strains of their structural and metamorphic involvement have reduced their resistance

to the agents of weathering, especially circulating ground water, carrying dissolving acids or acting directly in solution and hydration processes.

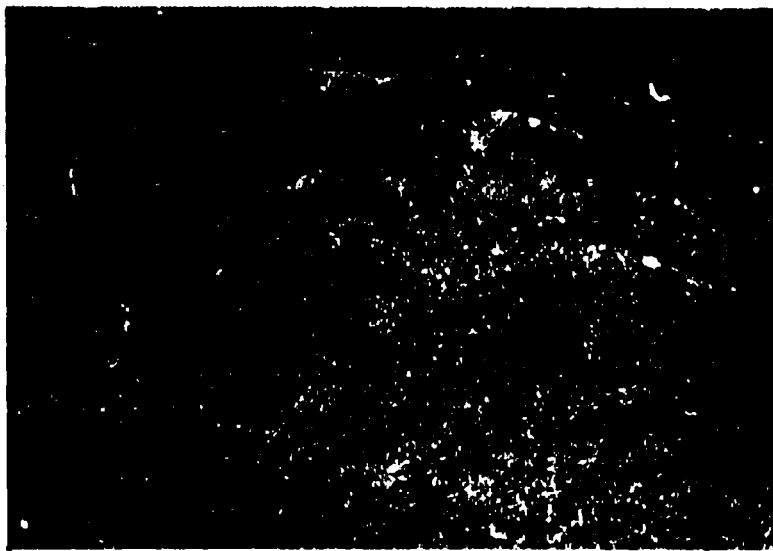
The inclination of layered or non-massive gneisses and schists and intrusive dikes and sills, and the development of cleavage, schistosity, jointing, and fracturing have contributed largely to the deeply weathered condition of most of the rocks of the area. Thick accumulations of saprolite, characteristic of much of the area, provide a measure of the depth to which weathering has extended, in some cases up to a hundred feet or more.

Massive igneous and metamorphic rocks commonly display exfoliation, sheet jointing parallel to the surface which results from the differential release of confining pressures as overburden is reduced in mass or weight (Figure 11). This physical phenomenon likewise contributes to the influence of penetrating water and decay solutions but because it is a near-surface development effects do not extend to the great depth seen in areas underlain by layered rock. A major result of exfoliation is the production of rounded profiles. The more granitoid biotite gneisses of the study area typically display this type of weathering and, in many cases, dome-shaped landforms have resulted (Figure 12 A). In contrast, elongate ridges with angular ledges appear to be more common in areas underlain by the layered schists and gneisses.

In the study area, the weathering and topographic expression of the Carolina series of rocks is related apparently to facies development within the series and therefore to the mineral composition of the rock types. The gneiss is found especially in the high country above 2500 feet

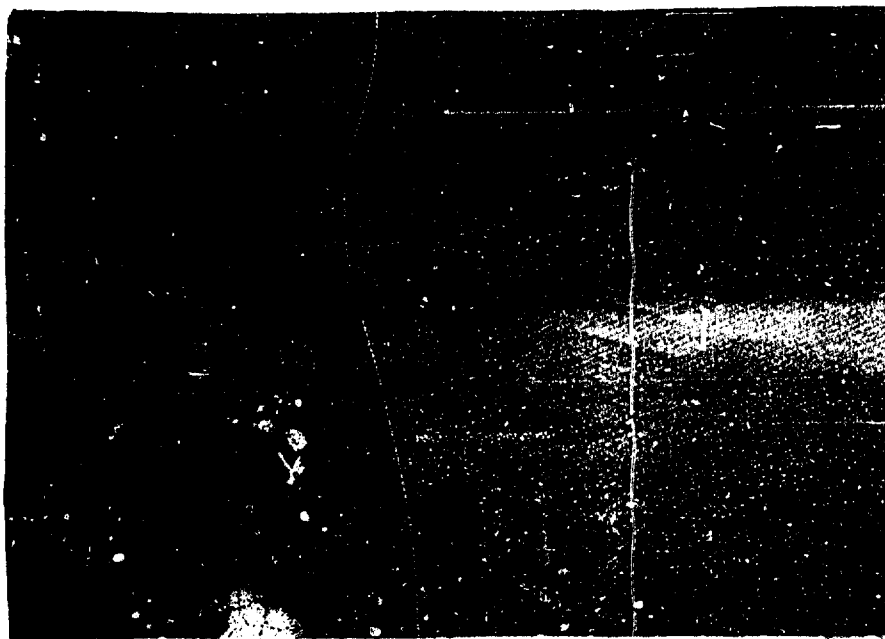


A-



B

Figure 11. Exfoliation in Carolina series biotite gneiss. A. Old quarry exposure on Highway 60 below Woody Gap. B. Closeup of sheet jointing west of Cooper Gap.



A



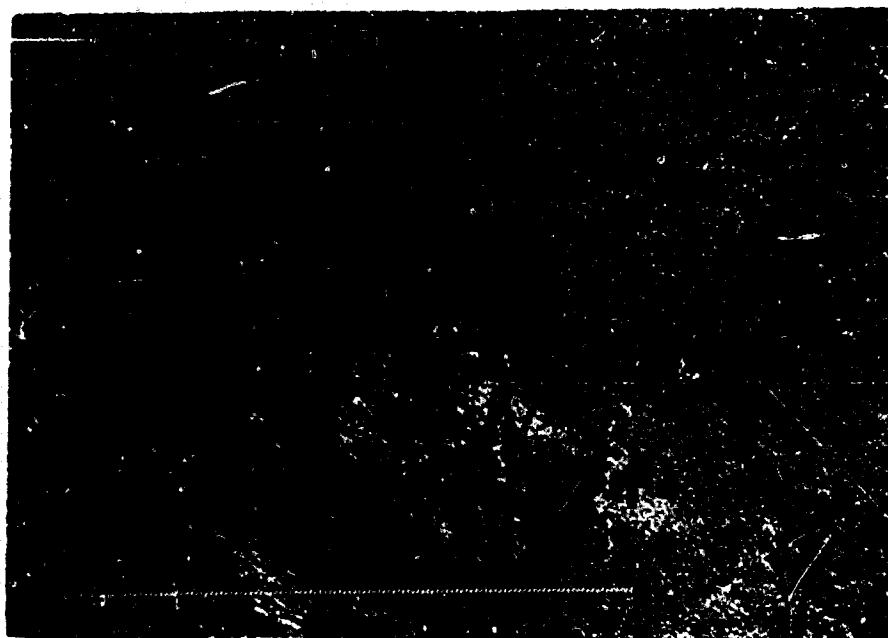
B

Figure 12. Linear ridge and rounded knob topography in the Ranger area. A. Knob development in the north central section. B. Southern mountain belt in the vicinity of Hawk Mountain.

forming mountains and ridges, peaks, and spurs (Figure 12 B). Weathering is generally deep. Large outcrops are not particularly common and solid ledges are rare except on the steeper slopes and along streams (Figure 13 A). In places, residual boulders and masses of large dimensions stand out above the general surface as less resistant material has been washed out around them. The most prominent occurrences of this feature are found near the crest of the southern mountain belt, especially on the high-angled, south-facing escarpment and its projecting spurs (Figure 13 B). This particular surface feature is considered further in the section dealing with microgeometry.

The inclusion of highly resistant garnet-kyanite gneiss in the Carolina series from Duncan Ridge in the northern mountain belt to Springer Mountain near the southwestern corner of the study is responsible for some of the highest relief in the area with many protruding ledges (LaForge and Phalen, 1913, p. 4). Ultramafic and granitic igneous injections into the Carolina series have introduced resistant masses which assist in maintaining the high relief. In many places where the series is exposed, the more resistant mica schist tends to obscure the actually wider occurrence of biotite gneiss which is reduced to residual clay and outcrops are rare.

The resistance of Roan series gneisses and schists depends to a large extent on the presence of siliceous layers which produce massive ledges and a blocky residuum. On the whole, however, the Roan rocks are less resistant and depressions are formed between large masses of Carolina gneiss which the Roan intrudes. It appears likely that several of the



A



B

Figure 13. Typical gneiss exposures and weathering in the high mountain sections. A. Outcrop on steep northeast side of Penitentiary Cove. B. Boulder development on top of Black Mountain.

major gaps in the southern mountain belt developed in this manner.

In the southern third of the area, particularly along the summit and south-facing flanks in the southern mountain belt, weathering of pegmatite dikes, lenses, veins, and masses, mostly intruding the Carolina gneisses and schists, produces clay bodies with more resistant quartz lenses and layers protruding. The dikes often contain muscovite mica. In these occurrences and elsewhere throughout the area, narrow stringers of quartz remain in the midst of large masses of saprolite following nearly complete weathering of associated rocks and the removal of soluble minerals (Refer to Figure 10 A, page 24).

The weathering of rocks in the study area generally follows a pattern based on the relative abundance of key minerals. Rocks high in feldspar; and carbonates (granites, biotite gneisses, and intermediate types) and hornblende (diorite, gabbro, hornblende gneisses and schists) are less resistant to erosion. Conversely, the lower the content of these minerals and the higher the content of quartz and mica, the greater is the resistance to weathering.

C. Pedology

1. Soil Types and Distribution

The soils of the study area are included in part in soil surveys of Fannin County (Phillips, et al., 1926) and Union County (Miller, et al., 1930). The soils of Lumpkin County have not been mapped. In the Fannin County survey, thirteen soil types in nine series are described, plus a category, "rough stony land," for areas with 15-90 per cent exposed surface

covered with stones and boulders. The latter category and seven types in five of the series are represented in the Fannin County portion of the study area. In the more recent and detailed Union County survey, more than 50 types and phases within 20 series are mapped, 30 types and phases within 15 of the series occurring within the boundaries of the study area. Porters, Balfour, Rabun, and some Talladega soils occur at the higher elevations (above 2500 feet), the Porters type being the most continuous and widely distributed of all types. At the lesser upland elevations, Fannin, Edneyville, Hayesville, Habersham, and west Talladega soils are typically developed on the hills and knobs of the intermontane basin. At the margin of the intermontane basin, Tusquitee and Tate colluvial soils occur at the base of some knobs and ridges. Terrace soils of the Altavista, State, and Wickham types are locally developed. Alluvial soils, some undifferentiated, others assigned to Congaree, Transylvania, and Toxaway types, are distributed discontinuously in the bottom lands along the streams. Diverse origins and histories have resulted in a highly complex pattern of distribution for the bottom land types, especially noteworthy along the Toccoa River and its tributaries between Gaddistown and Cavender Bridge. Soils assignable to Cecil-Applying types occur in the piedmont section.

2. General Characteristics of Soils

It is beyond the scope of the present report to examine in detail the individual characteristics of the great variety of soil series, types, and phases noted above. However, in order to present a somewhat comprehensive

review of the surface materials present in the area, a consideration of general features of the soils is given in the following paragraphs.

Three major categories of soils are present in the study area. Technically, these soils would be classified as Gray-Brown Podzols, Red and Yellow Podzols, and Lithosols (U.S.D.A. 1938, 1951). The azonal soils of the latter group range from "rough stony land" occurring at the highest elevations where slopes of 60% or more are common to the alluvial soils developed along the flood plains of the Tecopa River and its major tributaries.

The Gray-Brown Podzols are the most continuous and extensive soils in the area and except for occasional lithosol patches occupy most of the upland sites above 2500 feet on the average. They are characterized by organic mats, thin, gray A₁ horizons, and yellowish- to reddish-brown B (subsoil) horizons. Physically, these soils are generally friable in consistency and loamy in texture, silty or sandy at or near the surface, more clayey below. Derived from the typical gneisses, schists, and granitoid rocks of the study area, the physical characteristics of these residual soils are a reflection of the persistence of original minerals and the alteration and decay of others. Most noteworthy is the presence of mica flakes, principally muscovite, which have persisted from the original feldspars. Biotite mica, common in unaltered rock, is less resistant but occasionally persists in altered form as "vermiculite" (Denison, et al., 1929, p. 2). More often, the biotite has been weathered to kaolinite, adding to the clay fraction of the soils along with that

derived from the feldspars, equally abundant in parent rocks of the area.

The Red and Yellow Podzols differ from the Gray-Brown type in degree of laterization or inclusion of laterite materials. More than one cycle of development is apparent. While the underlying rocks are similar to those elsewhere in the study area, these soils tend to be sandier, coarser-textured, strongly leached, and comparatively low in organic matter. Heavy, red, yellow, or mottled clay subsoils are the rule and erosion has exposed them in many places. South of the southern mountain belt, these soils occupy piedmont sites generally below 2000 feet. Along the crest of the escarpment they occur in gaps only, for example, Cane Creek Gap and at the head of McAiry Creek near Goech Gap. In the north central and northeastern sections, they are found south of Mulky Gap between Spencer Knob and Wildcat Knob; north of Shope Gap; in the vicinity of Jones Branch along the road to the Teccoa Forest Experiment Station heading northeast of Baxter; just south of Baxter; northeast of the G.C.C. campsite; and along Williams Creek. Most of these locations are above 2500 feet. In the lower uplands (between 2000 feet and 2500 feet, usually), these soils are distributed in two general regions of some extent. Along the Forest Service road passing through Gaddistown, they occur somewhat parallel to the Teccoa River and along the lower courses of many of its tributary streams (Mauldin, Cochran, Frank, Davis, Grizzle, and Headtown Creeks). The second region includes Dunagan Mountain and the Skeenah Creek valley; the area north of Copper Creek to the south end of Licklog Mountain and west to Margret;

and along Rock Creek north of the Trout Rearing Station, all of these locations lying in the north central and northwestern part of the study area. Two smaller Red Podzolic sections are located south of Sarah along McAiry Creek to the southeast, and parallel to upper Youngcane Creek drainage on the north-facing slopes of the northern mountain belt. In general, the Red and Yellow Podzols are characteristic of the intermontane basin and bordering uplands, enclosed by and usually at lower elevations than the Gray-Brown Podzols. In both higher and lower upland sites, these soils originate from gneiss in some places, from schists in others.

Considering the soils of the Ranger area from a lithologic point of view, the Carolina series schists break down rapidly due to the inherent nature of such rocks but total decomposition is slow. Surface layers of soils derived from the schists are often extremely micaceous and contain numerous small fragments of undecomposed rock. Subsoils of biotite-muscovite schists are generally brown to red and sandy. Biotite mica schists produce red clay subsoils. The inclusion of other minerals such as kyanite, graphite, and sillimanite usually result in lighter, buff to gray subsoils, locally with considerable clay. These are well exhibited in the northern mountain belt. In the Ranger area, it can be observed that schists with original bedding planes and parallel schistosity oriented horizontally are overlain with thinner soils than those with angular orientation.

The gneisses, such as the common Carolina biotite gneiss, and granitoid rocks contain more soluble minerals, particularly feldspars.

As a result, however, deeper soils are formed, typically with red clay subsoils, light yellow occasionally. Garnet-kyanite gneisses associated with the Carolina series are extremely resistant to weathering and at the highest elevations of the northern mountain belt and along the western margin of the area develop the thinnest soils. Surfaces are liberally strewn with resistant boulders. In general, however, gneissic outcrops tend to be under-represented as compared with schists.

The Roan series gneisses and schists typically produce distinctive dark red (sometimes dark to yellowish-brown) clay soils which are among the deepest soils found in the study area. As is characteristic of amphibolitic rocks, weathering quickly removes the hornblende and alters the feldspars. Roadcut outcrops display rectangular remnants about the size of building bricks.

Soil formation over the larger pegmatite dikes produces blocks of resistant vein quartz scattered about in heavily micaceous sandy soil. Small detached mica books are occasionally found in such soils. Perhaps the best display of soils of this type is along the crest of the southern mountain belt escarpment.

In general, most of the soils of the study area are fine- to medium textured and well structured. These features, along with an abundance of organic matter for the most part, are conducive to moisture absorption and retention. Medium to well developed internal drainage appears to be the case for a large portion of the area. Moderately friable to crumbly surface soils and subsoils are most common although loose (noncoherent), compact, and plastic extremes are found in a number of situations. The

reddish-brown soils of the knobs and hills of the intermontane basin tend to become redder, denser, and more plastic as depth increases.

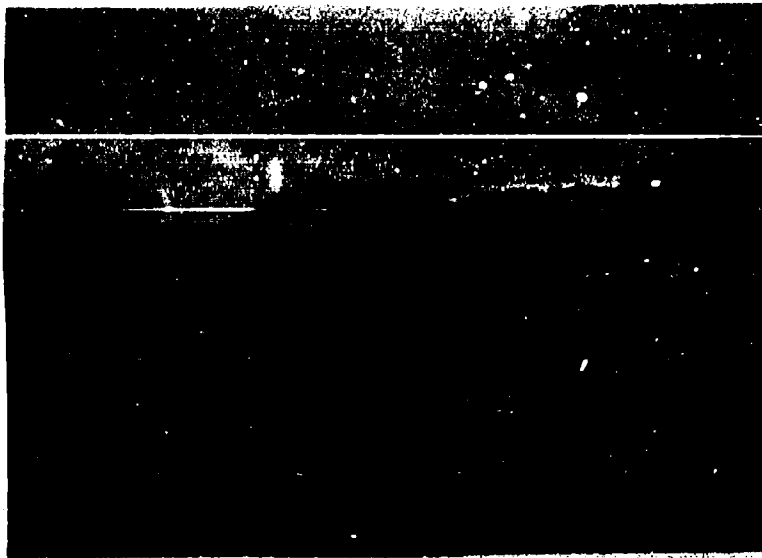
In the higher uplands above 2500 feet in the southern and northern mountains belts, the residual soils may be less than two feet deep in gneiss and granite areas strewn with many large boulders and smaller rock fragments. Soils of similar depth overly weathered mica schist in the northwestern part of the area in the uplands bordering the Toccoa River-Skeenah Creek confluence. On the summits of the linear and arcuate ridges in the southern mountain belt north of the escarpment, soils extend to five to eight feet depths above granite and hornblende gneiss bed rock.

In the lower uplands below 2500 feet in and around the intermontane basin, depths to weathered micaceous schist vary from two feet to five feet, reaching eight feet in areas underlain by granite gneiss, such as those bordering Grizzle Creek and Cavender Ridge on the north. The deep thicknesses of saprolite in many places, especially in the lower uplands, have been discussed in a previous section. In these situations, depths to bed rock may be as much as a hundred feet.

Colluvial deposits along the bases of slopes are judged to range from about three feet to eight feet in depth. Extension of such deposits over alluvium and other materials makes determination of depth extremely difficult, if not impossible, in places. Colluvial deposits accumulated in the high elevation gaps appear to thicken toward the centers of the gaps to unknown depths.

In the bottom lands flanking the streams of the area, normal flood plain or valley-flat alluvial associations have accumulated through flooding aided by sheet wash from the slopes. The surface material probably overlies older channel-fill and lateral accretionary deposits. Relict features of the parent material are preserved in many cases. Where they could be measured somewhat accurately, the bottom land soils averaged around three feet in depth. Disconnected patches of alluvial material occur along the upland portions of some of the streams. Such deposits have been regarded as older alluvium, some perhaps dating from earlier geomorphologic cycles. Among the alluvial soils of the bottom lands are the poorest drained and least developed morphologically. On the other hand, old alluvium along principal tributary streams displays fair to good subsoil differentiation (Figure 14 A).

Road cuts and stream dissection expose terrace deposits in several places, particularly along Little Skeenah and Skeenah Creeks in the northwestern part of the Ranger area (Figure 14 B), and to some extent along Rock Creek and the Toccoa River. There are at least two terrace levels, one within 25 feet of present stream elevations and another, older, level up to a hundred feet above. These are neither continuous throughout the area nor of equal development. Rounded quartzite sand and gravel layers with some boulders, reached at around six feet from the surface, are common to all these terraces, with depth of soil above the coarse material being half that figure in many cases. The typically yellowish subsoils of some streams terraces in the inter-



A



B

Figure 14. Alluvial soils. A. Old alluvium in valley south of C. C. C. campsite. B. Terrace along Skeenah Creek Valley northeast of Salem Church.

montane basin are compact when dry and plastic when wet. Remnants of the higher terraces are heavily dissected and redder in color.

3. Humus Development

Owing to the cooler temperatures prevailing in the uplands, coupled in some cases with the nature of the materials involved, the accumulation of plant residues in portions of the study area has become a pronounced feature. While not strictly considered as part of the solum by some definitions (U.S.D.A., 1951, p. 176), the thickness and areal extent of the fresh to partly decomposed plant debris is an important consideration in describing surface materials in the area. Furthermore, as the vertical dimensions of such materials en masse and individually increase, features of microgeometric significance emerge.

At 30 sites chosen for vegetation sampling (see Plate 10), the thickness and site coverage of the A_0 (F) layer of partially decomposed but identifiable organic matter and the underlying A_{1a} (H) layer of humus were calculated and observations were made concerning the nature of the material. Where present, A_{00} (L) accumulations were noted, especially if containing material of large size. In the following tabulation of data, the sites are grouped into geographic and, as nearly as possible, physiographic assemblages.

	Site	Elevation Interval	Thickness F (inches)	Per cent Cover	Thickness H (inches)
I. North Central section - valleys of creeks flowing south from northern	67	2250-2500'	0-4	85	0- $\frac{1}{2}$

	Site	Elevation Interval	Thickness F (inches)	Per cent Cover	Thickness H (inches)
	mountain belt: 65	2000-2500'	1-2	50	$\frac{1}{2}$ - $\frac{1}{2}$
	#67 - laurel leaves, twigs, barks, logs (10% coverage).				
	#65 - scattered leaves and twigs. Old pasture area.				
II.	Western border section - along 36&37	2000-2500'	$\frac{1}{2}$ -5	100	1
	Rock Creek: 68	2250-2500'	1-3	100	$\frac{1}{2}$ -1
	#36 - holly, hardwood, pine twigs, decayed logs.				
	#37 - pine needles, twigs, decayed logs.				
	#68 - 80% pine needles, twigs and limbs (35%) plus grassy spots; 2' bogs in creek.				
III.	Northern slope of southern 22	2250-2500'	0-4	60	0-2
	mountain sec- tion - south of 16	2000-2500'	0-5	80	0-2
	Cooper Gap and near upper Toccoa River headwaters: #22 - laurel leaves and twigs, hemlock needles.				
	#16 - leaves, twigs, pine needles.				
IV.	On or near crest of southern 66	3250-3500'	2-3	100	1
	escarpment: (west to east) 24	2750-3000'	1-5	98	1-2
	#66 (Puncheon Gap): leaves, 23	2500-2750'	0-6	60	0-1

	Site	Elevation Interval	Thickness F (inches)	Per cent Cover	Thickness H (inches)
twigs, ferns.	19	2750-3000'	1-5	65	1-1½
#24 (West of Horse Gap):	8	3250-3500	0-3	90	1-3
hardwood leaves,					
twigs,	10	3000-3250	0-2	50	½-2
decayed logs,	12	2750-3000	1-4	100	1-2
#23 (South of Horse Gap):	49	2750'	0-2	90	1-1½
undifferentiated leaves and	35	2750-3000'	2-6	100	1-1½
twigs.					
#19 (Southeast of Horse Gap):					
leaves, twigs,					
limbs.					
#8 (Summit Conner Mountain):					
Hardwood leaves,					
twigs, limbs.					
#10 (East of #8):					
undifferentiated leaves, twigs,					
limbs.					
#12 (Cooper Gap):					
oak leaves, twigs,					
other hardwoods					
debris, logs in					
late decay stage.					
#49 (Justus Gap):					
90% pine needles,					
10% oak leaves,					
twigs.					
#35 (Long Mountain summit): oak,					
laurel leaves, twigs,					
bark, logs.					
V. Southeast flank of Conner	4	2000-2250'	1-3	100	½-2
Mountain - along					
road:	5	2000-2250'	0-3	20	0-1
#4 (Southeast of road):	2	2250-2500'	0-8	35	0-1
pine needles,					
twigs; laurel	3	2000-2250'	0-3	45	0-½

	Site	Elevation Interval	Thickness F (inches)	Per cent Cover	Thickness H (inches)
leaves, twigs under clumps. #5 (Near #4): oak twigs and logs. #2 (North of road): oak leaves, twigs. #3 (South of road): pine needles, twigs, bark, logs.					
VI. South-facing slope of southern mountain sec- tion:					
	9	3000-3250'	1-6	100	1-1½
	7	2500-2750'	1-3	98	1-1½
#9 (Southwest of Cooper Gap): undifferentiated leaves, twigs, logs. #7 (East of Cooper Gap road): oak leaves, twigs, decayed logs (some chestnut). #11 (Half way between Justus and Cooper Gaps): hardwood leaves, twigs, logs.					
	11	2500'	2-5	100	1-2
VII. Stream valley, southern moun- tain belt escarpment- Etowah River Valley northwest of Zion Church: #31 (Near head of river valley):					
	31	1750-2000'	0-6	85	0-1
	30	1750-2000'	0-4	50	0-1
	1	1750-2000'	1-4	100	1
	13	1750-2000'	0-4	75	0-1

	Site	Elevation Interval	Thickness F (inches)	Per cent Cover	Thickness H (inches)
pine brush piles, slash #30 (Northeast branch valley): hardwood leaves, pine needles, twigs, brush piles, stumps, logs. #1 (Near Mt. Zion Church): oak, pine twigs. #13 (North of #1): hardwood leaves, pine needles, twigs; decayed logs. #14 (Northeast of #1): pine needles, twigs.					
	14	1750-2000'	1-1½	100	½
VIII. Near base of the					
southern	48	1500-1750'	1-4	100	1-2
escarpment:	41	1500-1750'	1-4	100	½-2
#48 (Camp Wahsega, south- east of Ward Creek): hard- wood, pine, laurel leaves, twigs; 20% cover of de- cayed logs and twig clumps. #41 (Northwest of Hidden Lake): Slash brush, limbs, twigs, pine needles.					

At some of the sites described above, the range in thickness shown for the F layer results from the absence or paucity of such materials in creek beds and on steep or washed slopes, and the development of thicker

accumulations against logs, tree bases, and the like. It was noted in the survey that within the boundaries of at least a third of the sites examined, 90-100% of the surface litter was burnable. In a short time after a rain, the F layer proved to be at least 50% dry in the sites along the southern escarpment crest but at one site, on the southeast flank of Conner Mountain, the F layer was wet nine hours after a rain. At the site near Mt. Zion Church, close to the base of the escarpment, 40-50% of the layer was dry eight hours after a rain.

The sites along the crest of the escarpment and the upper slopes have the thickest A₁ layers on the average; however, as expected in podzolic soils, this layer is relatively thin (ca. 2") in all cases. Mineral soil exposure is comparatively uncommon in these same sites. It does occur, however, in all but one site on the northern slope of the southern mountain belt and along the southeast flank of Conner Mountain, related in all probability to the concentration of moisture and consequent runoff, mainly as sheet wash.

Mor, mull, and duff mull humus types (Walker and Perkins, 1958, p. 9; Hoever and Lunt, 1952) are represented among the sampled sites in an 8:15:7 ratio. In sites where the humus could be classified as mor (pine stand) type, the A₁ layer is scarcely more than an inch thick on the average when present, whereas the same layer in the sites having the mull (hardwood) type is nearly 2½ times as thick. In sites where the duff mull humus type, with an admixture of pine and hardwood debris, is developed, the A_{1a} layer resembles the mor type in thickness and the A₁ layer approximates the mull type.

At the Cooper Gap site, where the identity of mull humus appears unequivocal, although a thin A_{1a} layer is developed, it was observed that the humus layers were dry a short time after a hard rain. This is in sharp contrast with the slower infiltration rate through mor type humus (Walker and Perkins, 1958, p. 35).

Those sites having the thickest mull humus layers are located at the higher elevations above 2500 feet. This is probably related to slower decomposition as a result of cooler upland temperatures. A possible bearing on the consistency of lower soil horizons with a high clay content may follow since plasticity is increased by the inclusion of released organic colloids (Grim, 1950, p. 10).

From the standpoint of pedestrian trafficability, an important consideration in Ranger operations, the extent and nature of the humus layers in an area such as this one would appear to be a matter of some significance. Within a vertical range extending from absence of humus cover through surface layers a few inches thick to brush piles and logs measured in feet are the means of negotiating a topographically diverse terrain with both maximum and minimum efficiency. At one extreme, debris of microgeometric dimensions are encountered as will be discussed in a later section. At the other extreme, the combination of shallow soils, heavy subsoils, high relief, and considerable precipitation has brought about the complete removal of top soil. Such truncated profiles are common in the area and where exposed on the surface create extremely difficult situations in terms of movement. Humus cover modifies these conditions to a great extent.

64

The influence of different types of humus on profile development results in variable subsurface conditions which in turn may be relevant to successful performance of a given military maneuver.

4. Cone Penetrometer Test

A cone penetrometer test of soils trafficability was made at vegetation sampling site 52 (See Plate 10) at one point during the field investigation. Although testing by this method was not continued, the results of the test are presented here to illustrate this mobility factor at one of the more difficult environmental situations encountered in the study area.

CONE INDEX

<u>Station</u>	<u>Surface</u>	<u>3"</u>	<u>6"</u>	<u>9"</u>	<u>12"</u>
Site 52, near Mauldin Creek	50	100	60		50
2/10 mi. W. of Forest Service	60	110	80		60
(Gaddistown) road, SW	60	120	80		70
of Cooper Gap; 2300 ft.					
elevation.	Averages: 57	110	73		60

Description: Alder thicket and swampy area.

A₀ - 1-2" (damp grass & leaves)

A_{1a} - 1"

A₁ - 3"

Soil soggy and wet with much partially decayed humus.

If an adequate sample was taken and a comparison with available data (Dept. of the Army, 1959, Table I) is justified, nearly all cone index values fall within the B (inorganic clay of high plasticity, fat clay) soils group range. However, because the sampling was performed on July 30, minimal values may have been recorded, and relating wet

season trafficability characteristics to the soil conditions at this site without adjustment of these values is probably not valid.

D. Surface Composition Summary

1. Classification of Materials

a. Introduction. In previous sections, a primarily descriptive, largely qualitative account of surface materials which contribute importantly to the physical environment of the Ranger area was presented, mainly for the purpose of establishing the range of variation in such materials. Despite the obvious diversity and complexity encountered in the area and revealed by the survey, an attempt has been made to reduce the magnitude of types and considerable technical detail to a single descriptive system.

As a result of particular emphasis or special interests, systems of classification have arisen from the study of surface materials which perhaps serve the needs of those similarly concerned but are of limited utility outside the field of application. Furthermore a profusion of technical terminology, often arbitrarily defined, limits the practical use of information so compiled. A comparison of soils and geologic maps of the same area based on different systems often shows little correspondence even though the object of interest is of the same fundamental composition to a large degree, and soil formation and weathering of rocks are inseparably associated.

Surface materials, such as rocks, no less than their biological counterparts, are products of evolution and environment. The analogy

may be carried further in suggesting that the problem of achieving a single system of classification for surface materials is, in effect, a problem of synthesizing evolutionary and ecological detail arising from several areas of emphasis. There is a close similarity here to the problem of integrating the separate matters of concern in biogeography as outlined by Dansereau (1951a, pp. 5-6), and many of the matters appear remarkably correlative when viewed in the context of the ecosystem. Among these are genetic composition, geographic distribution, topographic limitations, unit or association response to environmental factors or fluctuations in them, structure and composition of association, relationships to other associations differently organized, and effects of man's activities.

b. Systematics. After examining and enumerating by standard (i.e., "classical") methods the various surface components present in the study area through spot sampling and reconnaissance, predictable "behavioral" patterns with respect to weathering and relief emerged. These could be used in extending the survey further through extrapolation. However, in order to erect a classification system based on these observed characteristics but designed to satisfy the objectives of broader utility and, perhaps, ultimate quantification, it appeared to be necessary first of all to define or redefine certain parameters. Most of these were involved in the concept of "surface" itself, about which the following observations are judged to be relevant in the study area:

1. In an area of high relief, surface expression is as diverse as the topography, a matter of importance in the present study, since all surfaces regardless of inclination are significant in the Ranger operation. Trafficability problems of the Rangers extend from massive outcrops exposed on high angle slopes to incoherent deposits accumulated on reduced slopes. Differential weathering, stream dissection, mass movement, and mass transport have contributed to the diversity of surface slope and materials.
2. Although the materials involved in surface composition may be described within fairly discrete categories (rock types, soil types, etc.), the surface expression of these materials varies according to the nature of the exposure. As discussed in a previous section, metamorphic rock types dominate in the Ranger area. The uniqueness of these rocks resides in their megascopically recognizable parallel fabrication giving rise to foliation or schistosity. Other forms of cleavage, some inclined to bedding, others parallel to it, and cross jointing or tension fractures are characteristic of these rocks. As a result, bedding surface, tangential, axial, and transverse plane exposures of these rocks en masse display rather different features (See diagrams in Cloos, 1946, p. 19 and Grant, 1958, p. 43). Reaction to weathering, pattern and form of weathering, and development of soils are related directly to the type of surface exposed. For example, thin soil or none on an exfoliating surface may be one view of a granitoid gneiss, while a blocky, somewhat ledgy surface develops at some angle to the other.
3. In characterizing surface in the Ranger area, the vertical dimension (i.e., perpendicular to the lithosphere-atmosphere interface) is perhaps the most important, critical depth depending upon the nature of the material involved and/or topographic position. This profile includes soil horizons and humus cover where developed. The lower limit (base level) of consequence in this physiognomic view is variable. For the more resistant rocks, such as the gneissic and granitoid types lying at or near the surface in the high-land sections, the lower boundary of internal fracturing, or of the zone within which the inner surface (Penck, 1953, p. 47) is developed, may be regarded as such, whereas in the deeply weathered rocks, the water table defines the base level. The extent of development is a function of elevation, slope, maturity, and related factors involved in weathering and denudation. Normally, profile thickness decreases with increase in slope and denudation, and increases with decrease in slope and increase in depth of weathering.

Cohesion of materials increases in importance with increase in slope. Stability of the profile is a measure of relative mobility which, in turn, depends upon the nature of the material or its component parts. For example, a number of unconsolidated deposits are already mobile in the unweathered state, or become so in contact with water (Penck, 1953, p. 75). The role of vegetation in maintaining the profile and adding to it is obvious; the role of man in altering or destroying it needs no elaboration.

The system developed to classify the wide variety of surface materials present in the area is essentially lithologic in character with major emphasis placed on response to weathering and relative movement. Technical and additional descriptive details concerning special features of many of the types included in the system can be found in the previous sections. The system is described as follows:

- A. Hard Rock Surface - Divided on the basis of massive, bedded (foliated), or complex structure, the latter consisting of a central mass overlain by thick arching sheets. Massive types are gneissic to granitoid and occur typically above 2500 feet. Bedded types are schistose mainly but may be gneissic. While not confined to any elevation range, the schistose types are more commonly seen at the lower elevations. They are typically angular and ledgy, often folded and faulted, and produce the brighter colored soils. The complex type appears to represent an intrusive phase.
- B. Loose Rock Surface - Divided on the basis of implied degree and agency of movement or transport. Basically, this is the regolith of Merrill (1906, p. 287) and includes residual and transported subdivisions, specifically saprolite (Becker, 1895, p. 289), gap and slope colluvium, and stream alluvium (old and newer flood plain alluvium, and terrace deposits). Unconsolidated (incoherent) material for the most part, components range in size from gravel and coarse sand to silt and

clay, often in mixtures. Occasional resistant fragments, cobbles, pebbles, and remnant dike stringers are found locally. This material is found in gaps in the linear ridges of the mountain belts, along stream courses and near bases of slopes at the lower elevations, and in deeply weathered northeastern and northwestern portions of the area, occasionally elsewhere.

C. Combination (Mixed)

Surface - Consists of mixtures of A and B categories above with arbitrary percentage limitations. Produced by differential and extensive weathering of A types but to a lesser degree than any of the B types so derived. This surface is highly variable within short distances and is characteristic of intermediate elevations along the outer margin of the central basin sector.

Soils are included in all of the categories listed above. Azonal soils with little or no morphological development are associated with both the hard rock surface and recent alluvium of the bottom lands, at the two extremes of relief. Zonal soils are included in other surfaces, the Red-Yellow podzolic soils in the loose rock and combination surfaces, and the Gray-Brown podzolic soils in the hard rock surface and to some extent in the combination surface. Truncation of soil profile is common in the loose rock surface composed of saprolite. Humus cover may be present on all surface types in the manner discussed in a previous section of this report.

Recognition of rock types to comply with the system requires familiarity with gross characteristics only despite the complex mineralogic and petrologic variation described previously. Even so, in

crystalline belts of this type, gneisses grade into schists on the one hand and into granitoid igneous rocks on the other, often imperceptibly, so that divisions are arbitrary in many cases. Furthermore, rocks of diverse types metamorphosed under a similar environment commonly appear similar due to convergence to a homeomorphic type (Crickmay, 1936, pp. 1386-1387).

Further refinements to the system could be made by including textural, mineralogical, and other variations. As indicated in the mapping legend below, color can be used to differentiate among certain types and this in turn suggests zonal characteristics related to drainage and chemical reactions.

2. Distribution

On the following pages, several strip maps, located by grid numbers on Figure 15, have been used to locate examples of surface materials present in the Ranger area. Time was not available to extend the survey to the point of drawing boundaries for specific types. However, it is felt that the strip maps (Figures 16-23) contain a representative sampling which can be extended as the occasion warrants. The following legend, codified by a letter-number system, defines the symbols used on the strip maps:

- A. Hard Rock Surface
- 1. Massive (Gneissic-Granitoid)
- 2. Bedded (Foliated)(schistose mainly, occasionally gneissic)
 - a. Grey (gneissic variety)
 - b. Reddish (schistose variety)
 - c. Dark Brown

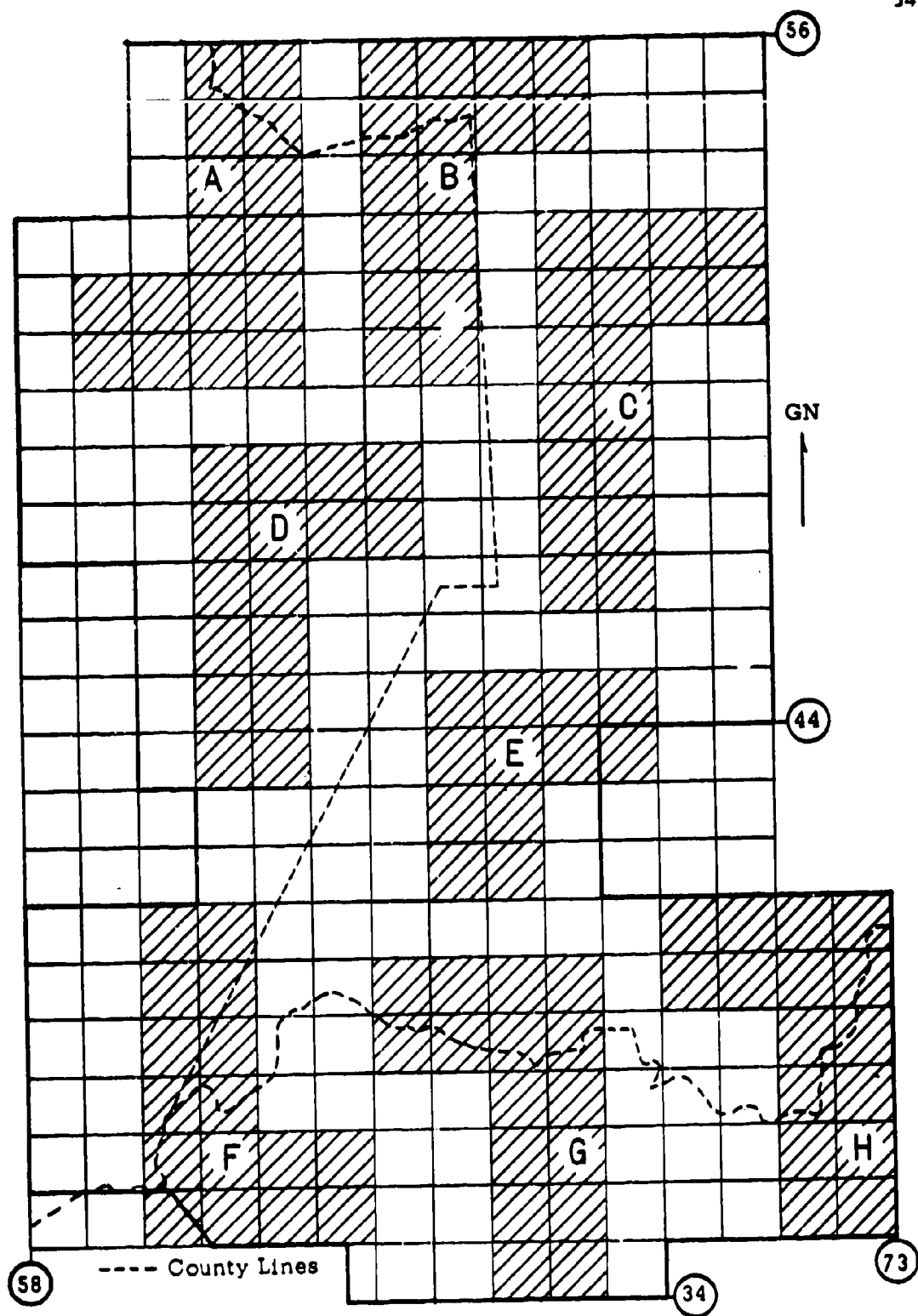
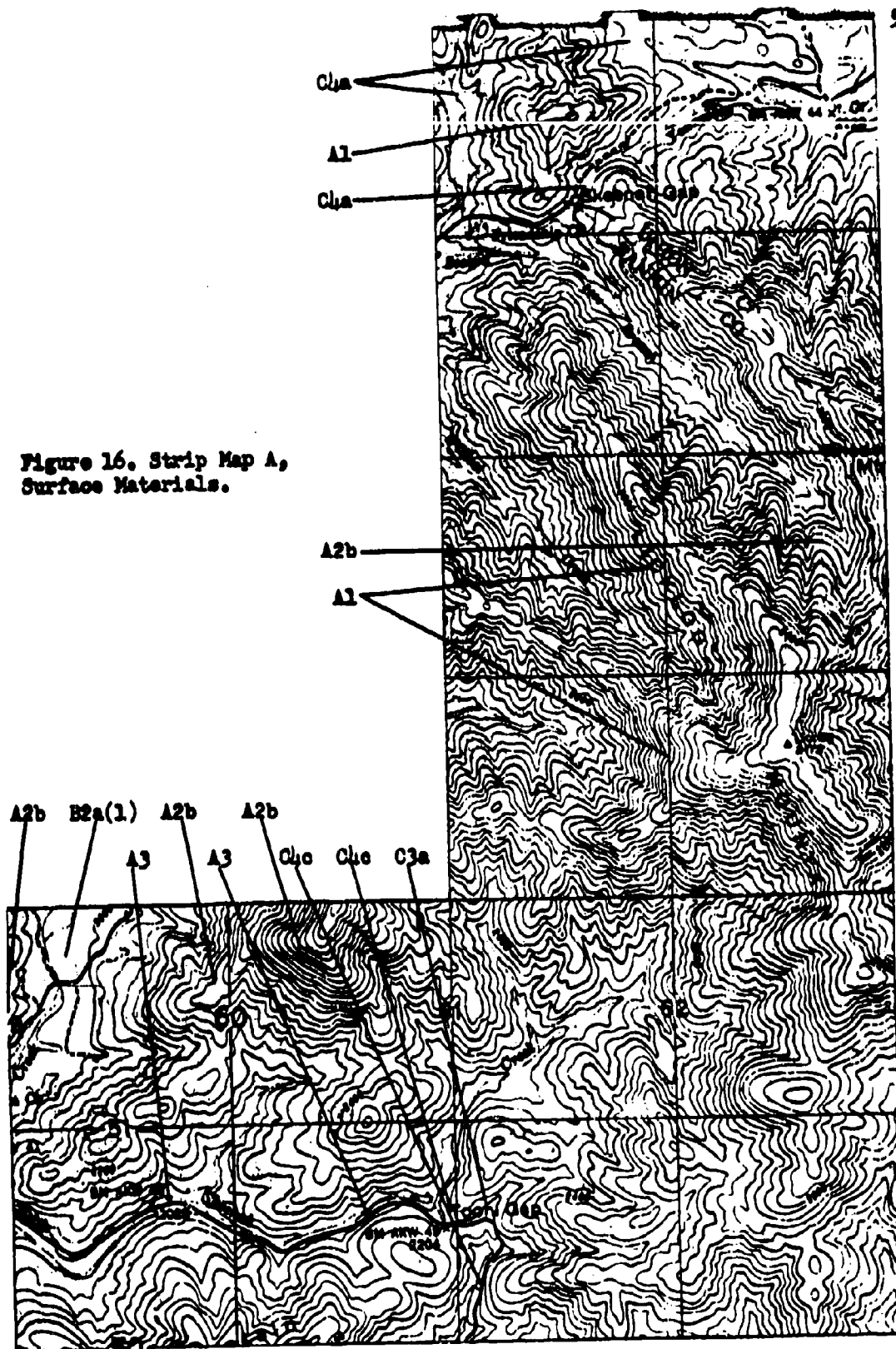


Figure 16. Strip Map A,
Surface Materials.



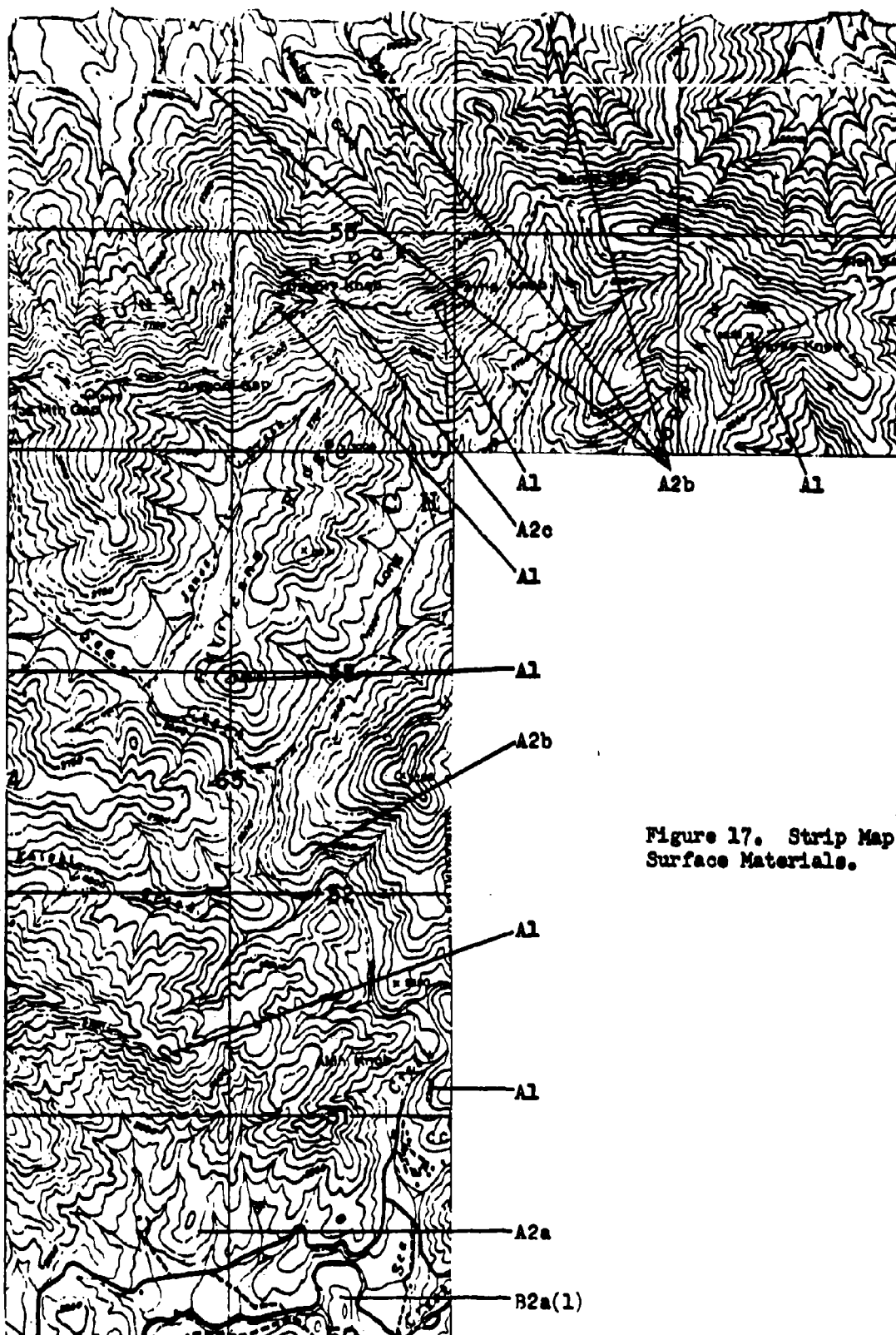


Figure 17. Strip Map B,
Surface Materials.

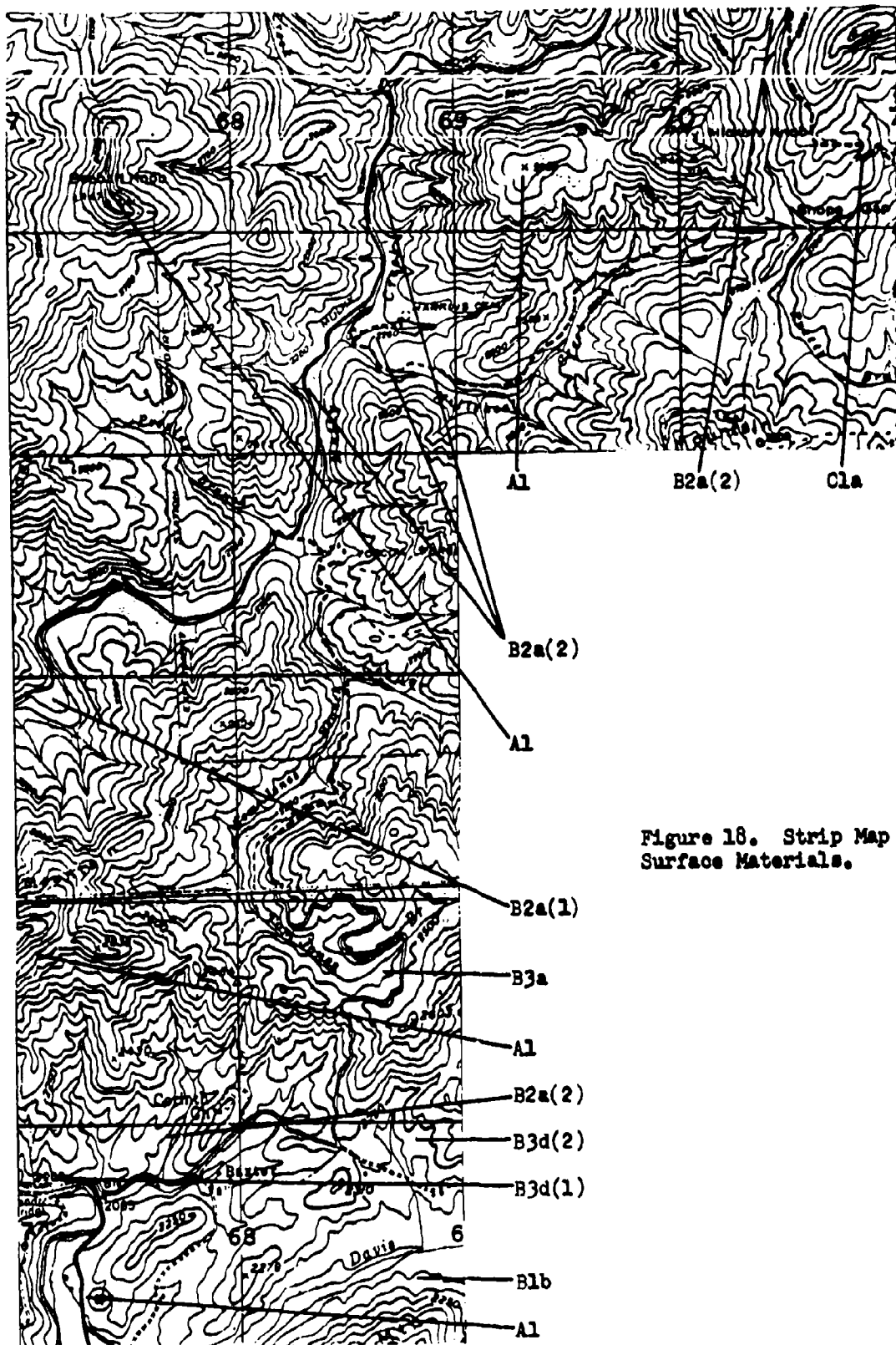


Figure 18. Strip Map C,
Surface Materials.

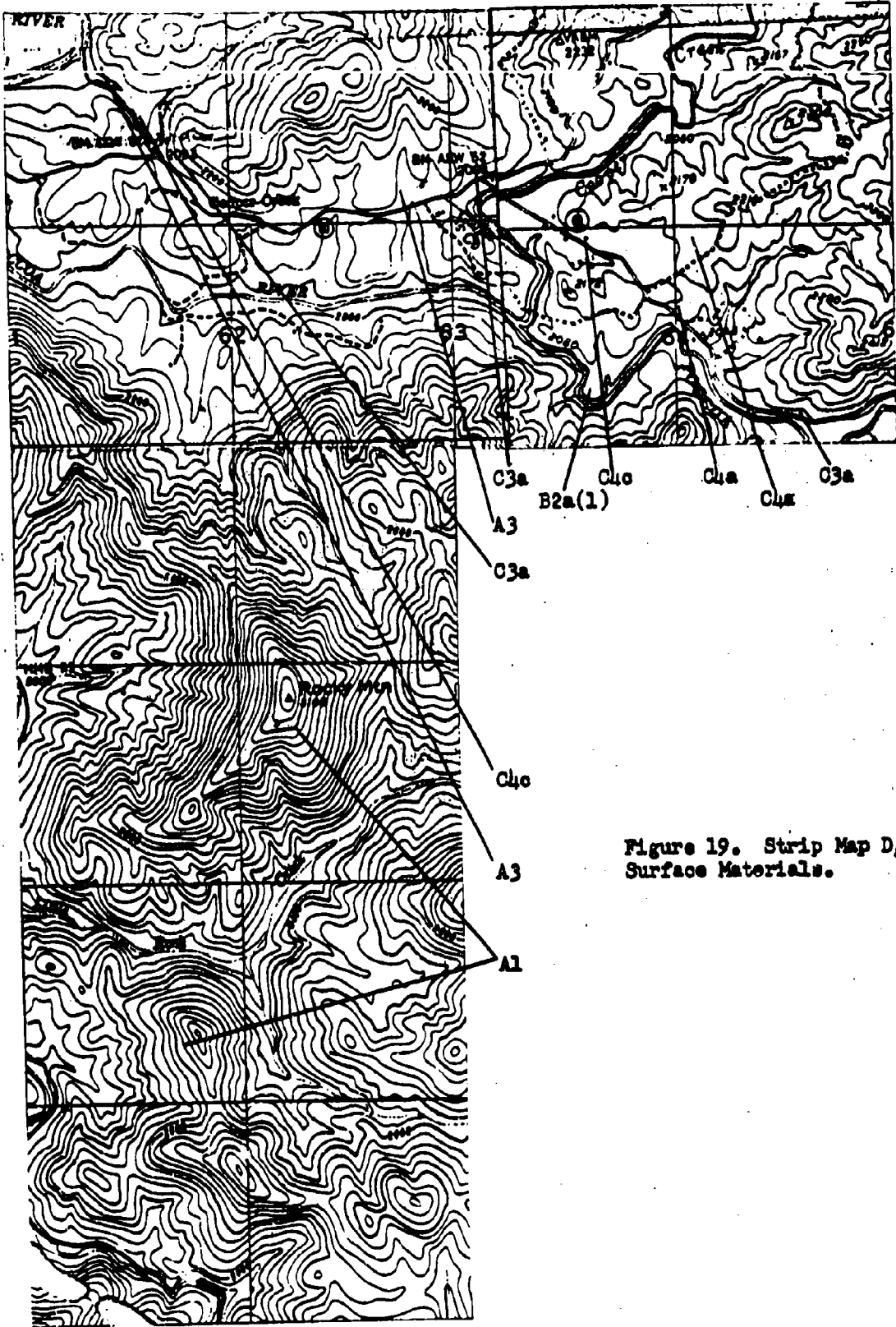


Figure 19. Strip Map D,
Surface Materials.

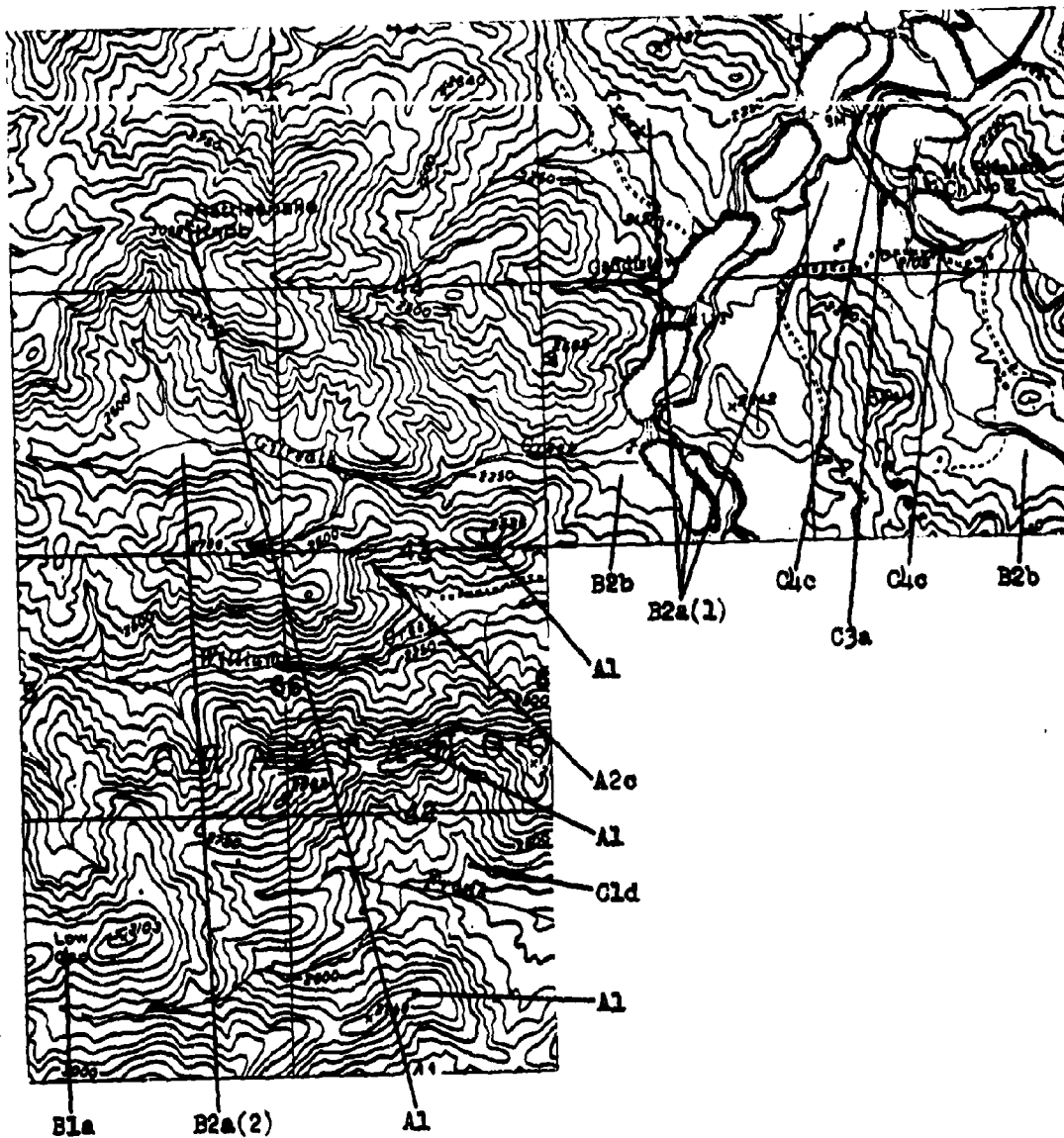


Figure 20. Strip Map E, Surface Materials.

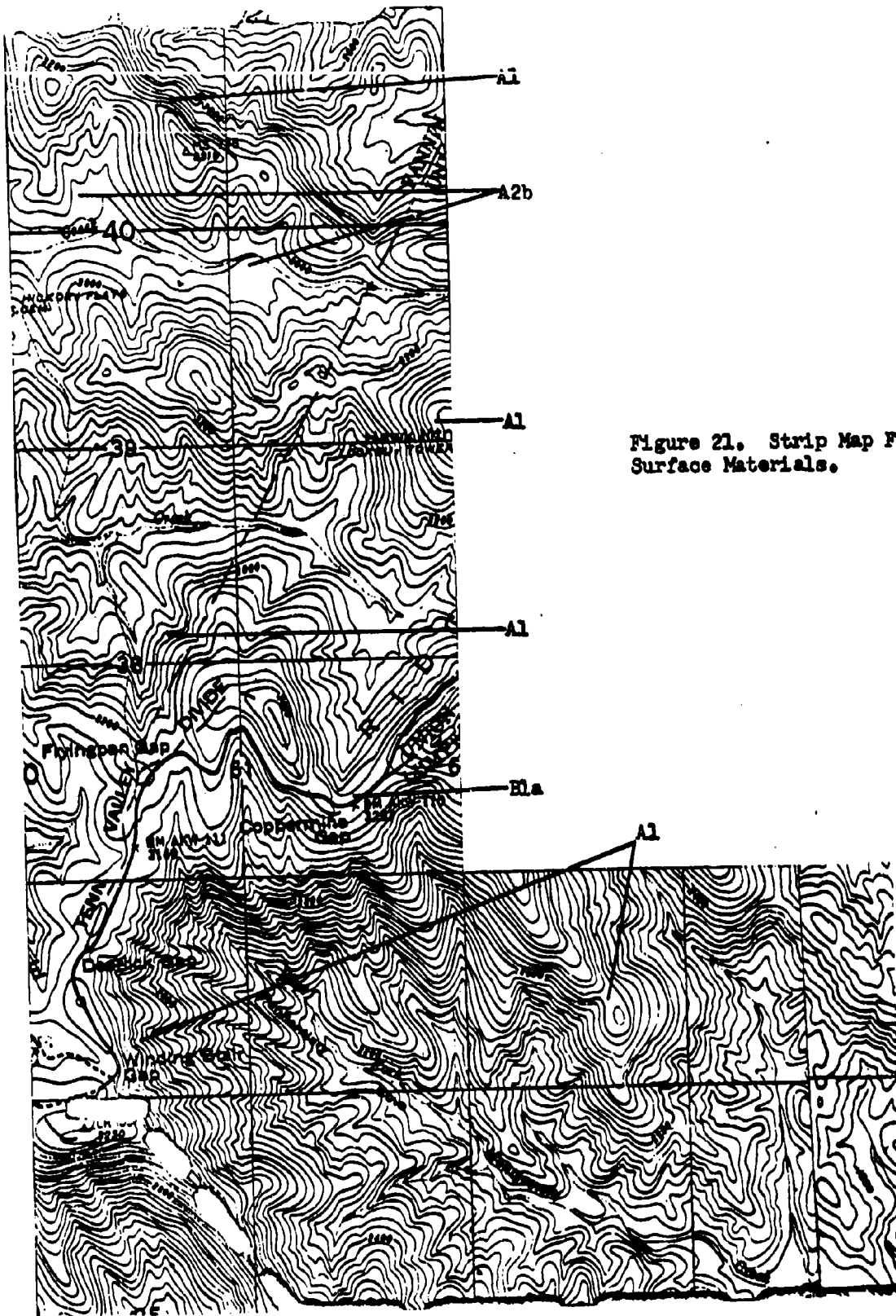


Figure 21. Strip Map F,
Surface Materials.

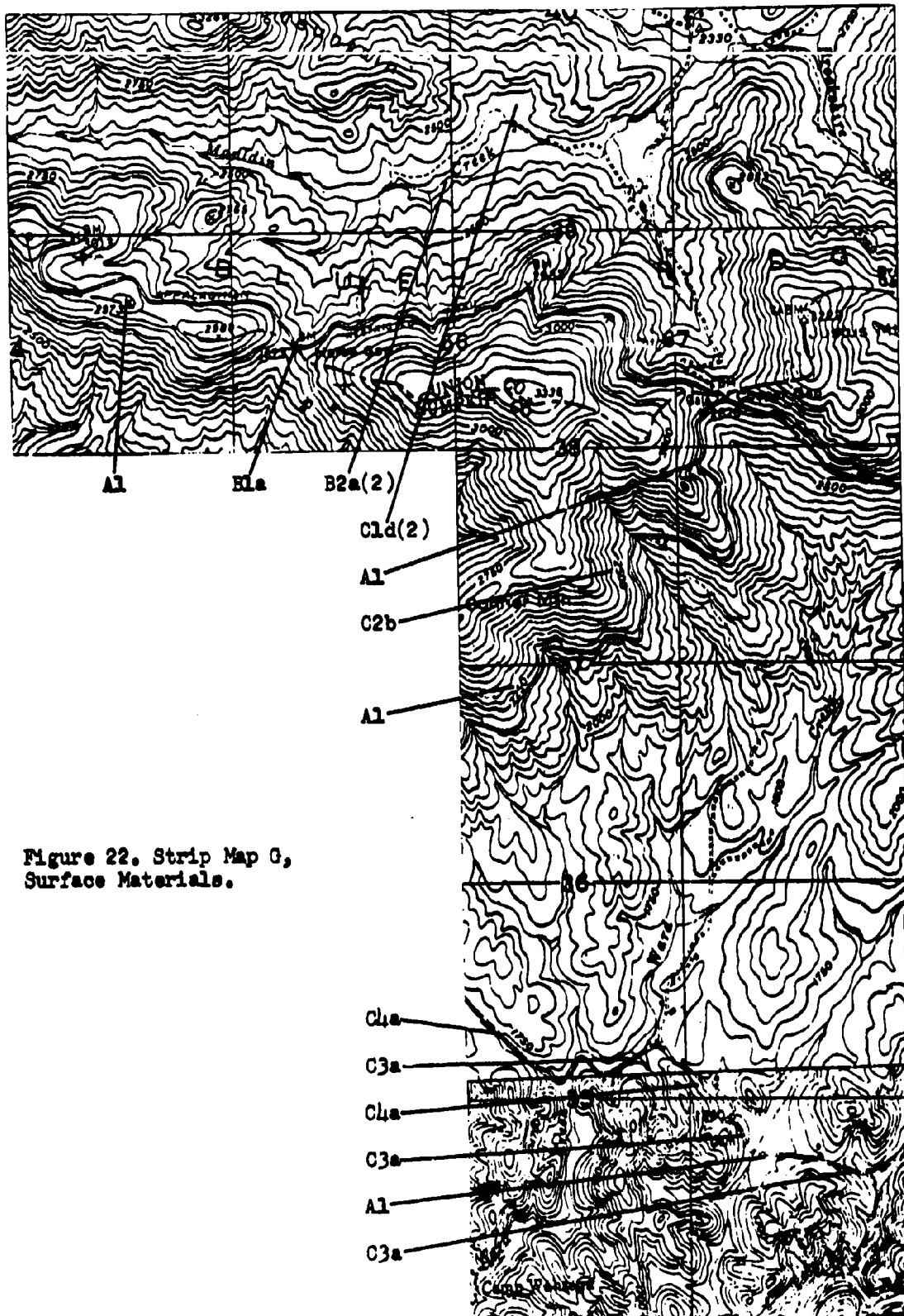


Figure 22. Strip Map G,
Surface Materials.

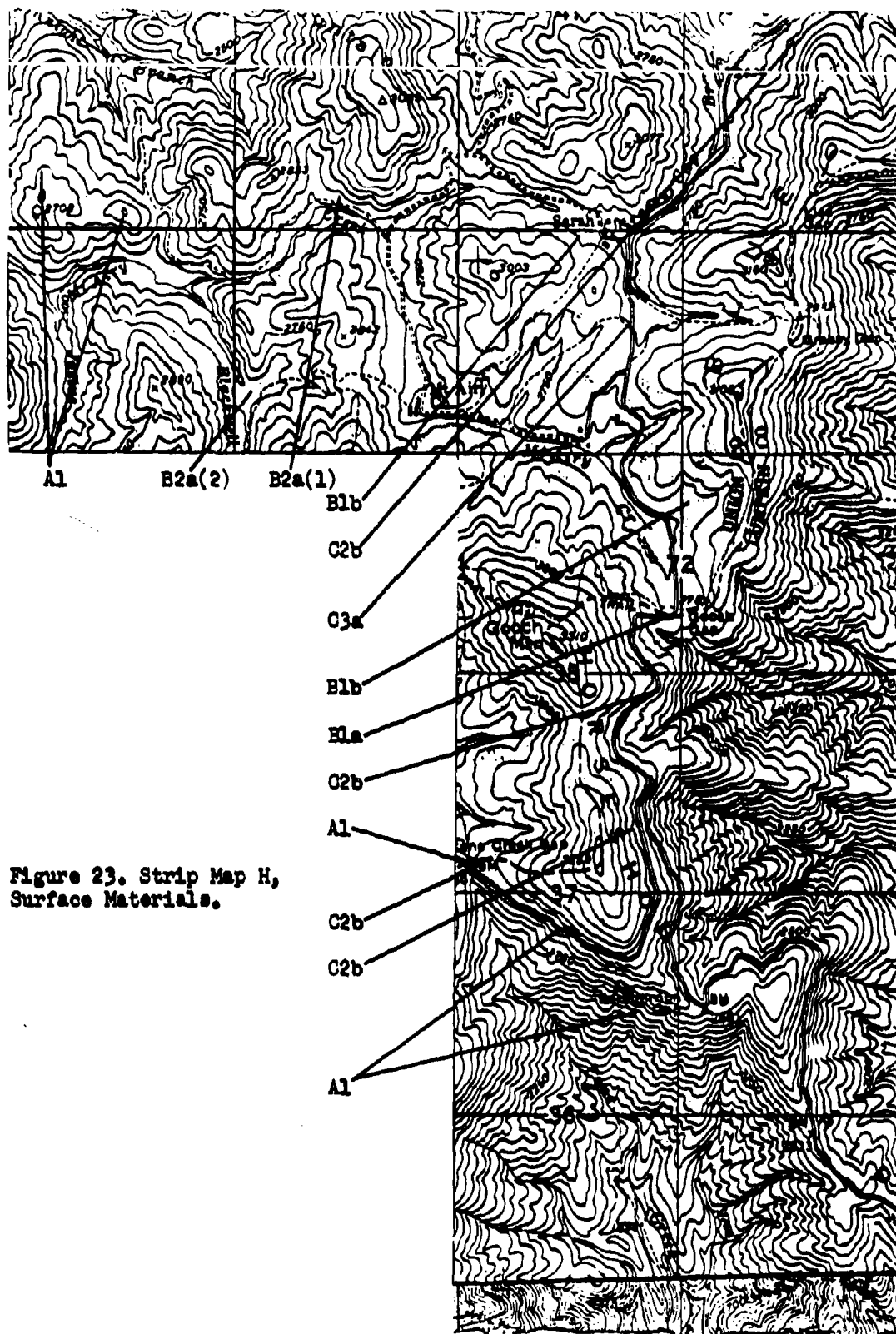


Figure 23. Strip Map H,
Surface Materials.

- B. Loose Rock Surface
 - 1 Colluvium
 - a. Gap
 - b. Slope
 - 2 Alluvium
 - a. Bottomland
 - (1) Recent
 - (2) Older
 - b. Terrace
 - 3 Residuum (saprolite)
 - a. Purplish-red
 - b. Light brown
 - c. Dark brown
 - d. Bleached red
 - (1) Occasional thin dike stringer
 - (2) Completely saprolitic

- C. Composition (Mixed) Surface
 - 1 More than 50% A1 plus B3*
 - 2 50% or less of A1 plus B3*
 - 3 More than 50% A2 plus B3*
 - 4 50% or less of A2 plus B3*

*B3 may have a-d color variations listed under B3 in the previous category and the particular letter is then added, eg., C1a

Example: A2c is a hard rock surface composed of dark brown schistose rock, probably had good profile development, and is ledgy in vertical exposures.

The foregoing survey of surface materials was not intended to represent more than an introductory venture into the matter of quantifying a variety of surface materials present in a complex, crystalline area. Rigid controls are lacking due to the time limitations imposed on the study. Much more data with wider coverage is needed; the practicability of collecting such information at the sites selected for vegetation sampling is outweighed by prejudiced results. Further definitions are required in the system, as for example, in the differentiation between hard and soft rock which might appear to be simple. Deeply weathered metamorphic rocks possess internal weaknesses not apparent in surface view.

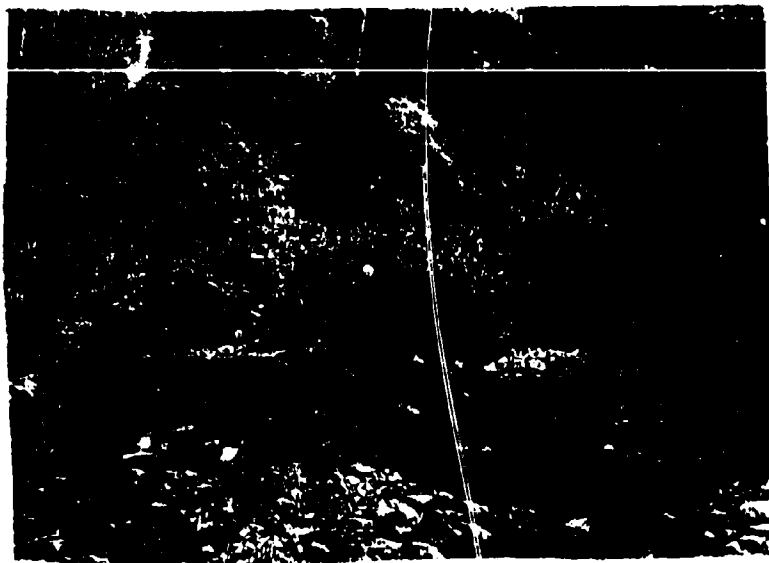
E. Hydrology and Hydraulic Geometry

1. General Hydrologic Features.

The surface streams draining the Ranger area have been developed in patterns closely associated with the physiographic divisions described in a previous section. The southern escarpment and piedmont is drained from southeast to southwest by tributary streams of the Chestatee-Chattahoochee (Apalachicola Basin), and the Etowah-Cartecay-Coosawattee-Coosa (Mobile Basin) systems. The northern slopes of the northern mountain belt are drained by tributaries of the Nottely-Hiwassee subsystem which joins the Toccoa-Coosa subsystem to form the southernmost portion of the Tennessee Basin. The Toccoa River and principal tributaries drain the greater part of the area in a roughly centripetal pattern converging in the central intermontane basin.

The headwater tributaries of the Toccoa River originate at around 2950 feet in elevation and descend to about 2200 feet west of Ball Mountain where the main trunk of the Toccoa proper is formed. Within a short distance, the river reaches a grade of 12-15 feet per mile and continues at or near grade thereon. On the steeper slopes of the escarpment on the opposite side of the Tennessee Valley divide, more rapid descent of streams in narrow V-shaped gorges provides a contrast in gross hydrologic features (Figure 24).

The drainage pattern exhibited by the Toccoa River and its tributaries is complex. The main axis of the headwater portion is oriented in a north-south direction between Justus Mountain and the



A



B

Figure 24. Hydrologic features in the Ranger area. A. Development of surface drainage east of Three Forks near western boundary. B. Upper Etowah drainage along the southern escarpment.

gap between Cavender Ridge and Cavender Mountain. West of the axis, drainage is strongly trellised with east-flowing creeks separated by high, parallel ridges independently joining the main stream at nearly right angles. East of the axis, Mt. Airy-Canada Creek drainage of the southeastern portion of the area is well developed and roughly dendritic within an upland basin of some extent. Beyond Gaddistown, the Toccoa flows, in a circuitous, meander-like fashion with many angular turns, within a sediment filled valley which sporadically narrows and widens. Strath-like, bouldery terraces, previously noted, occur along the sides of the valley in many places. Outside of the upland, headwater portion, the velocity of the stream, which appears to be near grade over much of its course in the area, is not impressive. Resistant outcrops create patches of increased turbulence locally, these alternating with quieter stretches or pools.

Southwest-flowing Cooper Creek and its tributaries, draining the northeastern part of the area east of Licklog Mountain, and Skeenah Creek and its tributaries in the northwestern part, provide most of the drainage for the northern mountain section, widening and extending the valley flood plain considerably at points of junction with the Toccoa River.

"Pavements" of resistant boulders carried from the uplands commonly floor the stream channels. Downcutting is limited and the relatively shallow banks are rapidly filled during periods of high rainfall. Flooding occurs annually and valley passage in several places is restricted during periods of maximum precipitation (40% of the precipitation falls in

March and December according to T. V. A. records). Surface runoff is reduced to a great extent by the forest cover and the absorptive nature of some of the underlying rocks and thick residuum.

2. Basin Analysis

Drainage basin characteristics of the Toccoa River from headwater branches to the junction with Cooper Creek were analyzed in the manner described by Strahler (1952, pp. 376-380 and earlier papers). Analysis of linear form elements produced the following data:

Stream Order	Number of Segments	Bifurcation Ratio	Average Segment Length (Feet)	Length Ratio
1	154	4.82	2400	1.99
2	32	5.33	4780	3.40
3	6	6.00	16270	3.10
4	1		50500	

Since the bifurcation ratio is not constant, differences in rock type and/or stages of development are suggested, uniform climate being assumed for the whole basin. The length ratio between first and second order segment length is lower than expected although ratios between higher orders are similar.

A comparison of areal elements was made between the upper Toccoa River basin and three sub-basins incorporated within it: Suchas Creek, Mauldin Creek, and Headtown Creek. Basin shape was determined by applying the circle method used to measure the elongation parameter in macrogeometry. The following results were obtained:

Basin	Area	Drainage Density	Basin Shape
Toccoa River	41.2 mi. ²	3.09	- - -
Suches Creek	8.0 mi. ²	3.38	0.388
Mauldin Creek	2.0 mi. ²	3.13	0.314
Headtown Creek	0.9 mi. ²	3.52	0.409

Regardless of size, drainage density in all basins is similar and would be described as low, averaging $3\frac{1}{2}$ miles of channel for every square mile of surface. This map value is probably less than true value because of the amount of slope present in the area. Forest coverage may account in part for the low value; the resistance and massiveness of the rocks underlying parts of the area and the permeability of residuum in other, deeply weathered parts are probably contributing factors.

3. Hydraulic Geometry

During the course of the investigation, a limited study was made of hydraulic characteristics of streams at selected sites in the area (Figure 25). Range poles were placed on each side of the stream at a level judged to be the high water mark. The zero end of a metallic tape was secured to one of the poles. The tape was held taut between range poles and kept level with a hand level. An ordinary level rod was used to determine the vertical distance from the tape to the ground or to the bottom of the stream. Horizontal distance was measured from the zero end of the tape to each pole position. Cross sections were plotted from data thus obtained. These have been submitted as accessory information but have not been analyzed further.

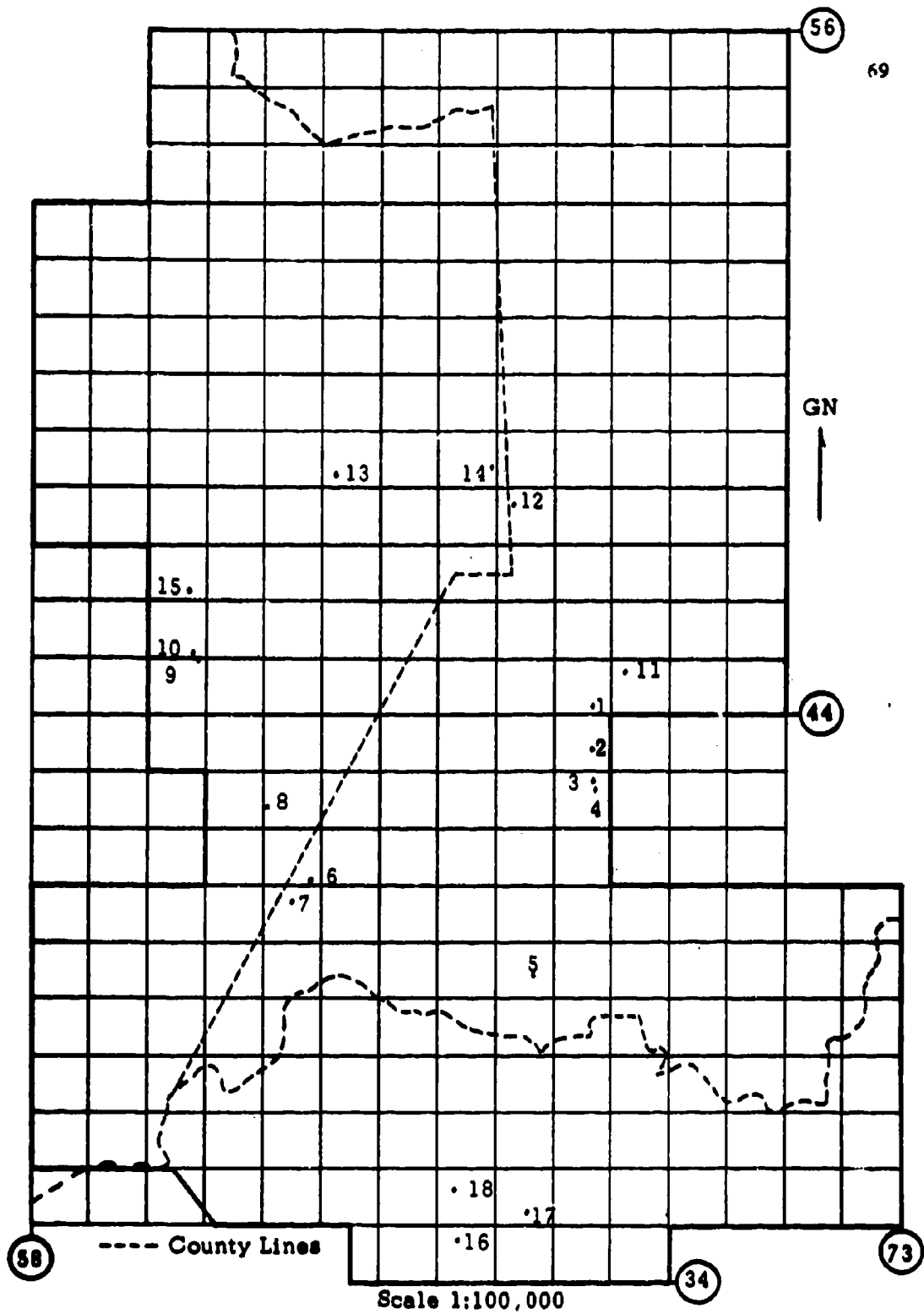


Figure 25. Hydrologic data sites.

Bottoms examined at all sites were firm and mostly rocky. Using flash bulbs for floats, surface velocity was measured at each site and determined to be approximately 2 feet per second on the average.

F. Microgeometry

1. Sampling

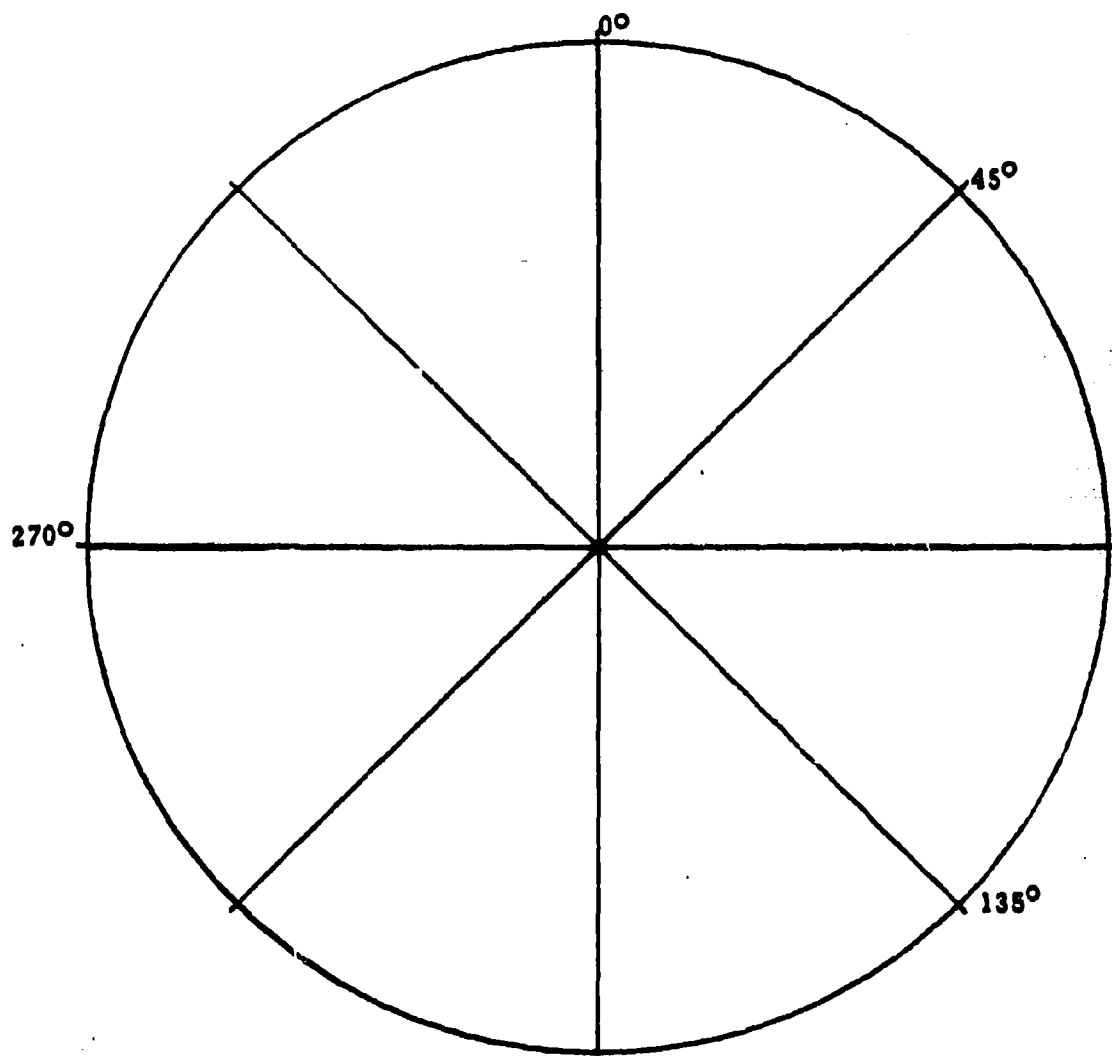
Using information contained in Plan of Tests, Tropical Soil Studies (Waterways Experiment Station, 1961) as a guide, a field technique for recording the occurrence of those features in the Ranger area having relief of less than ten feet was devised. Two data recording forms patterned after those illustrated in the manual cited above were prepared (Figures 26 and 27).

For maximum efficiency the microgeometric data were collected at the vegetation sampling sites where such features were judged to be a significant factor in surface relief. Range poles, a metallic tape, a Philadelphia leveling rod, and a hand compass constituted the field equipment used in the technique described as follows:

1. The center of a 60-foot diameter test area was located within 10 feet of the center of the vegetation site. A range pole was placed at the center point and the zero end of the tape was attached to it at a convenient height (approximately 3.5 feet) above the ground. Due to the height of the microgeometric features encountered in the study area, the suggested height of 35 cm in the manual proved to be impractical.

Project CE-9

Measurement of Length and Bearing of Microgeometry Features



	L Length of Feature	B Bearing of Feature
Crest 1		
Crest 2		
Crest 3		
Crest 4		
Crest 5		
Crest 6		



1 in. = 10 feet

Figure 26. Form for plotting measurement of length and bearing of microgeometry features.

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ENGINEERING EXPERIMENT STATION

Project CE-9

Dahlongega Area

Elev. _____ Slope _____ (%) Toward _____ Coordinates _____

D = Distance from center of test area in feet
H = Height from surface to stretched tape in feet

Figure 27. Microgeometry measurements data sheet.

2. A second range pole was positioned at the edge of the test area and the tape was held taut between the poles, generally parallel with the slope of the terrain. Objects encountered along a ray directed from the center of the site were noted, and the horizontal distance from the center (H) and the distance from the tape to the ground (D) were recorded. The level rod was used to determine the (D) distances. Values of (D) and (H) were recorded for each significant change in microrelief. While the upper limit for these features was set at ten feet, the criterion for the lower limit depended on the inferred importance of the feature with regard to Ranger mobility.
3. A compass was used to determine the recommended eight rays along which data was to be obtained, the first ray being oriented in the direction of true north. After recording data at two sites, it became apparent that this method was very time-consuming and, furthermore, too much data was collected near the center of the test area while more important features at the edge of the area were not recorded. A variation in the method was then devised that is believed to portray the important microgeometric features in the Ranger area more accurately. This variation is based on the observation that on the predominantly forested upland slopes where significant microgeometric features, such as (1) numerous



A



B

Figure 28. Contrast in surface conditions. A. Microgeometric features minimal. B. Microgeometric features pronounced and possibly significant.

dead logs in contact with the ground, (2) loose, flat rocks which slide downhill under a man's weight, (3) massive rock outcrops protruding above the general surface, and (4) smaller fixed rocks, are most pronounced, some of the features had definite orientation with respect to slope. As a consequence, data for eight sites were collected along two rays parallel to up slope and down slope directions without regard to compass headings. Plan views of the features were drawn and diameters of logs and protruding rocks were measured as in the first method.

Including the sites involved in the measurements discussed above, notes on the distribution of microgeometric features were made at a total of 33 sites, each assigned the number of the vegetation site for reference.

3. Results

Data sheets have been submitted as separate accessory information. Notes taken at vegetation sampling sites included cover percentage estimates, as in the following examples:

Site #30	Coverage:
Elevation 2000'	7% Rocks
Slope 45%, S15°W	2% Fixed (8"-14")
	5% Loose (3"-6")
	2% Dead Logs (15" & 30")
	6% Sticks ($\frac{1}{2}$ "-2"), scattered

The important microgeometric features of the Ranger area can be summarized as follows:

<u>Area</u>	<u>Feature</u>
1. Wooded	Dead logs
2. Rocky and Wooded	Massive rock outcrops, loose rock, and "slip rock" (disc-shaped rocks, 6"-2' in diameter, which slide under a man's weight)
3. Cultivated flats	Especially in the lowlands bordering the Toccoa River, fields are laced with drainage ditches measuring 2 feet in width and 2-3 feet in depth on the average; streams in general become more significant as microgeometric features in the lowlands where depth and width increase.

Some percentage estimates computed at sites where microgeometric features in category 2 above especially predominate are listed below:

<u>Site</u>	<u>Cover</u>
2	60% loose talus, 1"-2' above surface 20% fixed 8-10' extending 1-4' above surface Granite gneiss, some schist
3	16% loose talus, 1"-2' above surface 4% fixed, 1-3' Granite gneiss
6	16% loose talus, 1"-2' above surface 4% fixed Biotite gneiss.
11	10% loose talus, blocky 15% fixed, projecting 3' above surface Granite gneiss
12	40% loose rock, 1-3' above surface 20% fixed, 1-3' in dia., 3' in height Biotite gneiss

<u>Site</u>	<u>Cover</u>
19	50% loose rock, 1-3' above surface 20% fixed, ranging from 1-18' above surface Biotite gneiss
23	25% loose rock, 1-4' above surface 70% fixed rock, projecting 6-18' above surface

Reference to the vegetation site map, Plate 10, will show that each of the sites is located either on the south-facing slope of the escarpment at or near the crest or on the southeastern flank of Conner Mountain. Commonly further characterized by accumulations of logs or other debris, these rocky sites probably contain the most pronounced microgeometric features in the Ranger area (Figure 28).

3. Discussion

In gathering microgeometric data in an area such as this one, 8-rayed circular plots are impractical when employed on slopes that may approach 85% and where, incidentally, such features as described above commonly occur. Rays longer than 30 feet are required to adequately sample such features. For obvious reasons, collection of data of this sort should be carried out in the late fall or winter months; undergrowth obscures many of these features and otherwise inhibits sampling.

The relative importance of objects of microgeometric proportions which lie on steep slopes is a matter that seems to require further examination. It seems reasonable to predict that degree of slope would become a limiting factor long before these features became effective in restricting movement.

III. MACROGEOMETRY

A. Introduction

In the manual prepared by the Vanderbilt University group (Dept. of Civil Engineering, Vanderbilt Univ., 1962), macrogeometry is defined as the gross topographic configuration of an area, and includes all attributes of the surface that are defined by the slope envelope generated by a 10-foot contour interval. Previous investigations have determined that it may be possible to describe the macrogeometry of an area by using six or seven parameters to describe terrain units. A terrain unit as defined by the Vanderbilt group is an area which encompasses one dominating topographic high and is bounded by a continuous topographic minimum. The technique used in drawing and analysing terrain units in the present report was patterned in general after methods outlined in the Vanderbilt manual.

B. Macrogeometric Analysis

1. Determination of Terrain Unit Boundaries

The Vanderbilt study indicated that on the basis of the study of the Colesburg quadrangle, approximately fifty per cent of the terrain units in a given area should be analysed. It was concluded in the present study that the boundaries of all terrain units in the entire area could be drawn in considerably less than twice the time it took to draw boundaries for half of the terrain units. Drawing all of the

boundaries on the quadrangle sheets proved to be an aid in detecting boundaries that were in error.

Multiple topographic highs situated closely together were treated separately instead of as a unit because of the large contour intervals (40-foot and 50-foot). Small knobs, which were actually minor highs on a large topographic high also presented a problem. It was decided that such minor highs would not be the basis for drawing a separate terrain unit.

2. Terrain Unit Analysis

Approximately half of the terrain units were analysed, and the units to be analysed were randomly selected. The planar shape of the terrain unit defined by the Elongation number, E, was the first parameter determined. The method used to determine Elongation is as follows:

- (1) The diameter of the largest inscribed circle of the terrain unit was recorded as D_1 .
- (2) The diameter of the smallest circle to enclose the terrain unit was recorded as D_0 .
- (3) E was solved for using the equation:

$$E = D_1/D_0.$$

A template was designed to use in determining Elongation. It consisted of a transparent sheet of plastic on which circles having a common point of tangency were drawn. The diameters of the circles increased by one-half inch increments from $1\frac{1}{2}$ " to 7".

To determine the profile shape and size, four lines were drawn from the topographic high to four randomly selected points on the boundary of the terrain unit. The longest line was designated as profile PP₁. The other profiles were designated PP₂, PP₃, and PP₄ by proceeding clockwise from PP₁. The following parameters were determined using profiles:

relief (R)
dissection (D)
profile area (A)
peakedness index (S)
slope (Q)

These parameters are shown in Figure 29. Each of these parameters will be discussed in detail later. Successive profiles in a terrain unit were analyzed until average values for the parameters were determined using the following:

$$\% \text{ Diff.} = \frac{\text{Avg. Value (n profiles)} - \text{Avg. Value (n-1 profiles)}}{\text{Avg. Value (n profiles)}} \times 100$$

where value means parameter value.

When the per cent difference was 5% or less, the computations were carried no further, and the average value of the parameter for n profiles was considered to be the average value of the parameter for that terrain unit. Four to seven profiles were enough to obtain the average values of the parameters in nearly every instance.

The last parameter determined was parallelism number (P), and the method used to determine P will be discussed later in the report.

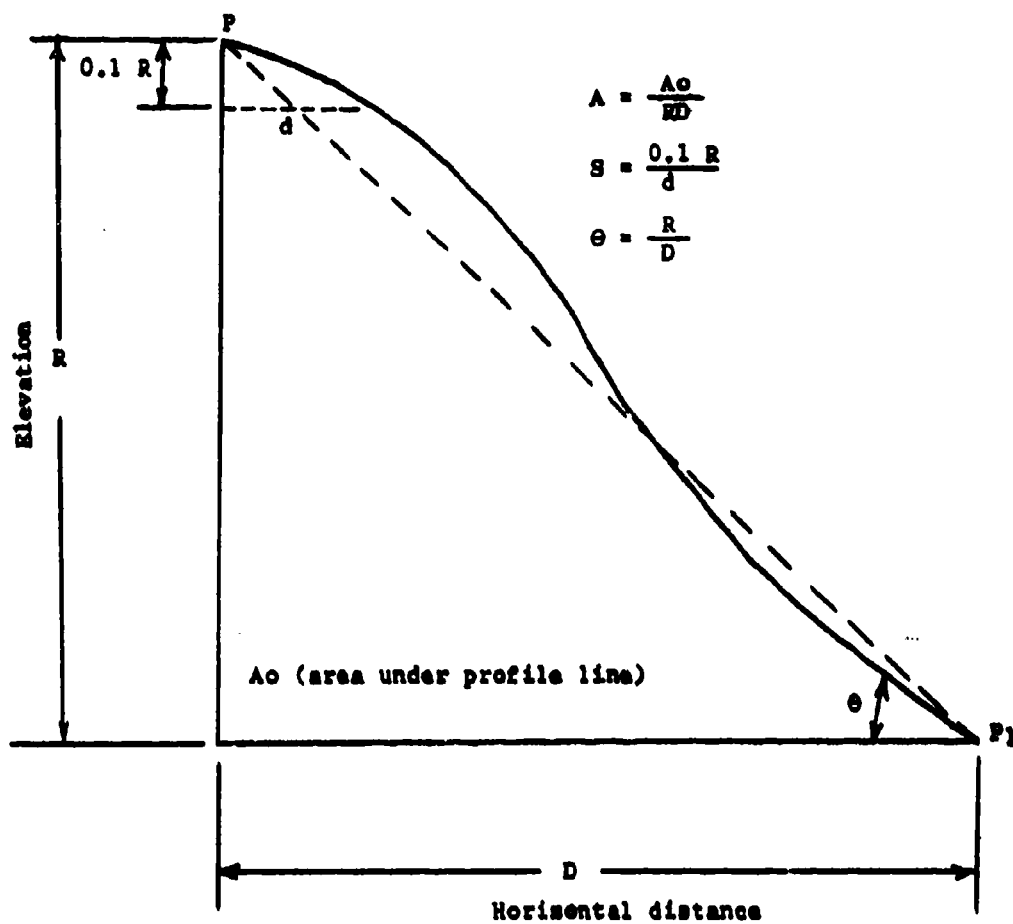


Figure 29. Typical profile.

C. Elongation Number

Proven statistical methods for investigating and describing terrain units and for seeking out those parameters which yield the most information with the least expenditure of time and energy is probably superior to any other method or combination of methods known. Sampling techniques not only speed data collecting but allows for detailed observations, and rapid consideration of many variables (Peltier, 1962, p. 24). These data which are treated statistically can be converted to standard units which often facilitate comparisons. While no method of analysis is without some error, statistical analysis will reveal the level of reliability desired. Statistical analysis is the unassailable continuum between investigators, the investigated, the past, the present, and the future (Robinson, 1963, p. 15).

Consider the collection of elongation numbers from the Mountain Training Area. The frequency distribution graph (Figure 30) of the numbers approximates the superimposed normal curve. The same relationship can be shown on probability paper. An arithmetic test for goodness of fit can be made by using the χ^2 test. This particular collection of numbers is characterized by a sample mean of 0.512 and a sample standard deviation of 0.118. These are unbiased estimates of the respective population parameters. A relatively short range into which successive sample means will fall has been calculated. This can be done at any level of confidence desired with, in most instances, an upper limit of 99%. It should be noted that the sample size n for determining the confidence

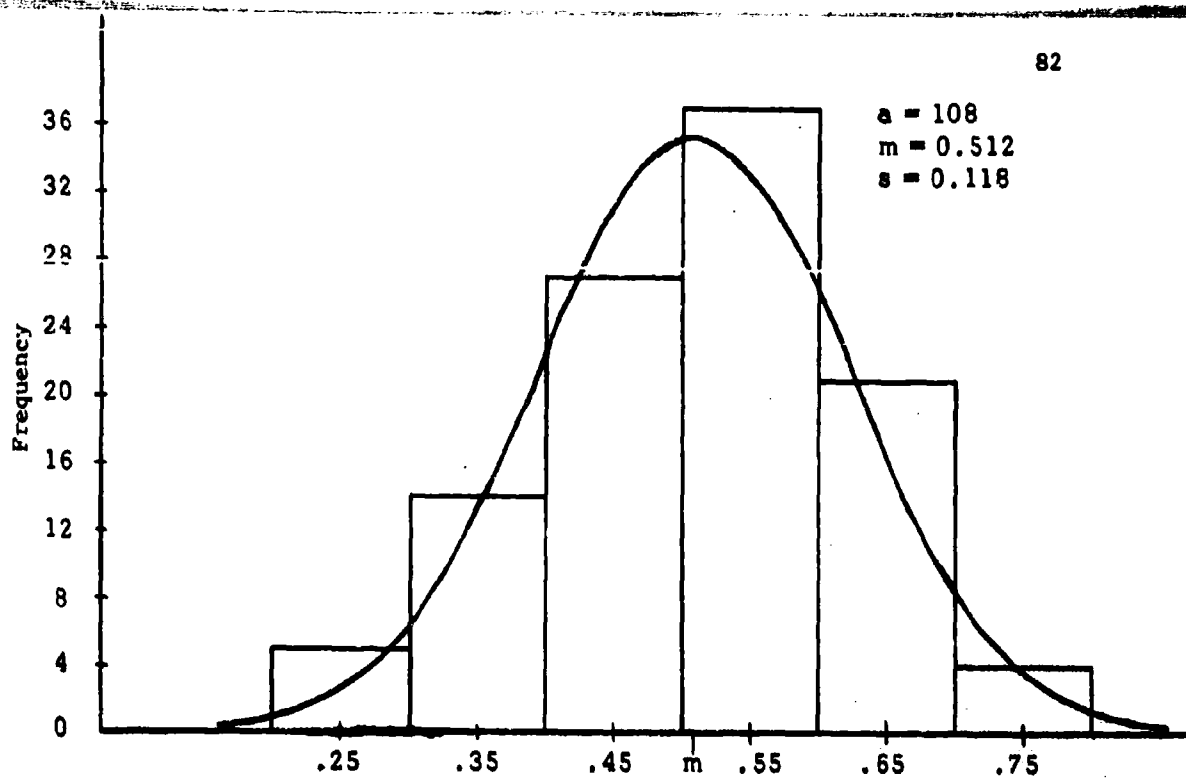


Figure 30
DISTRIBUTION OF SAMPLE ELONGATION NUMBERS

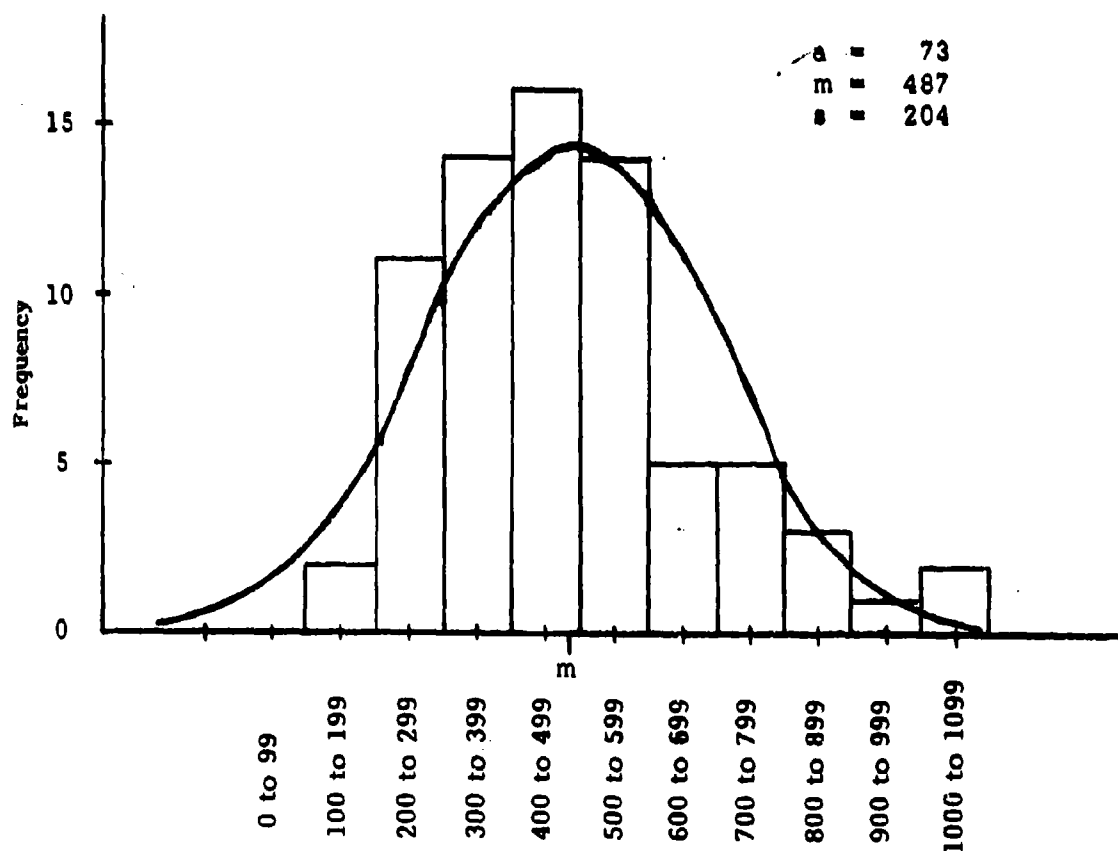


Figure 31
DISTRIBUTION OF SAMPLE RELIEF VALUES

interval is independent of the size of the population (Figure 32). A potential value of such a procedure is that it can be used in a test of the hypothesis that given equivalent geology, physiography, and climate in another area, the same degree of elongation will be encountered.

The distribution of elongation numbers is mapped at a confidence level of 90% (Plate No. 1). The units indicated on the map are actually the upper and lower values amounting to 5% of the sample for each extreme. These are the highly elongated and nearly round units, respectively. Most of the area, as estimated by the sample mean and standard deviation, is characterized by elongation values between 0.32 and 0.69. That portion of the map is left blank. Upon determining the elongation of all terrain units, it was found that very nearly 10% of the elongation values actually do lie within the extreme ranges as predicted from the sample. Those terrain units, drawn in addition to the sample units, which had values less than 0.32 or greater than 0.69 are referred to as "areas in error" on Plate No. 1.

D. Relief

From a high point in the area, it can be seen that most of the high knobs and mountain tops stand at very nearly the same level. Within the area stream dissection has carved valleys creating varying amounts of local relief. The distribution of relief is shown in Figure 31. The sample highs and lows are mapped on Plate No. 2.

In some instances it may be desirable to show a relationship between related sets of data. If the portion of the study area between

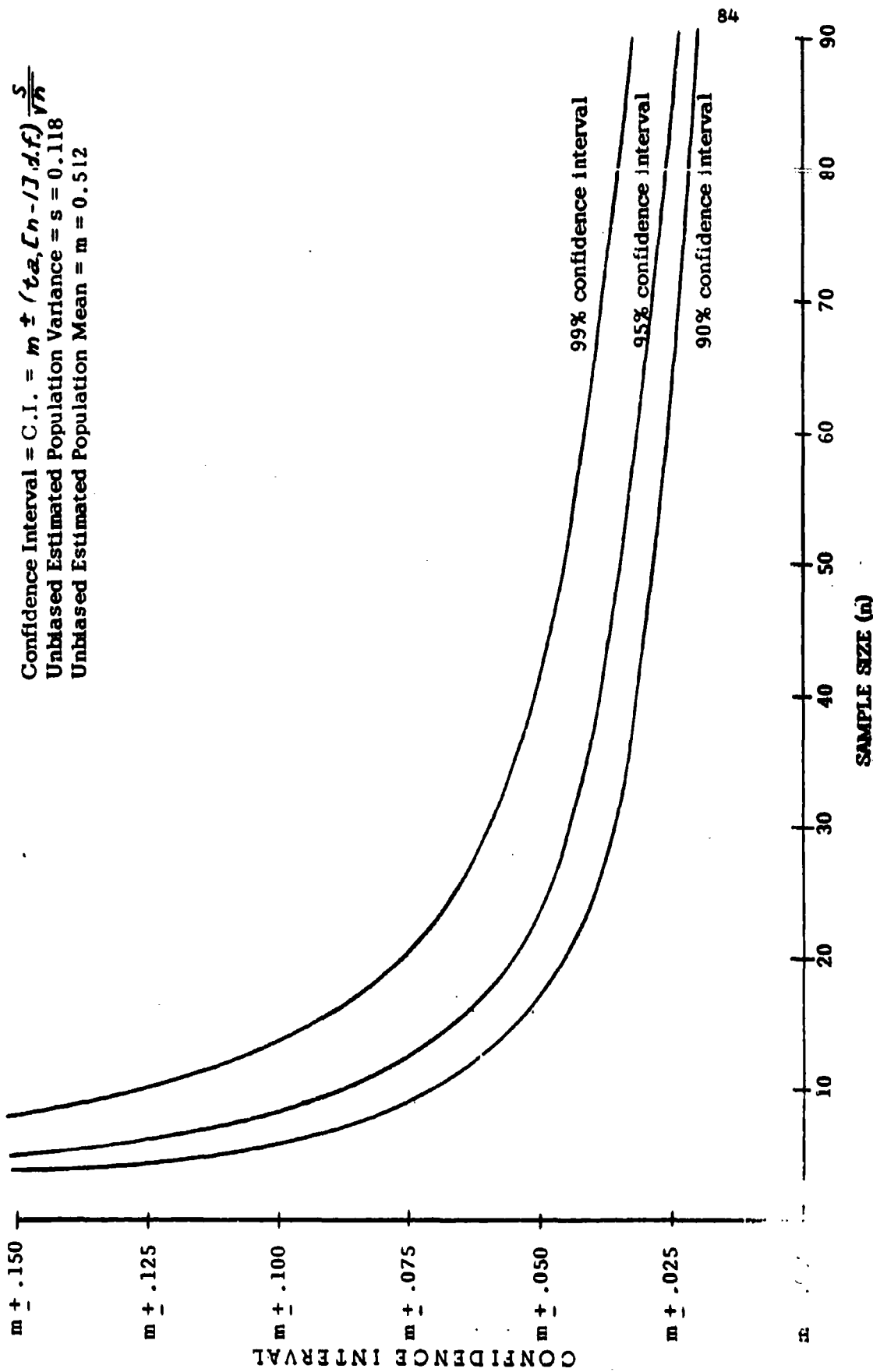


Figure 32. CONFIDENCE INTERVALS FOR SAMPLE MEANS WHERE $s = 0.118$ AND $m = 0.512$

the horizontal grids of 39 and 56 may be thought of as a collection of residual knobs or monadnocks, then one is probably justified in suspecting that a positive correlation between the elevations of the high points and the corresponding local relief does exist. Eighty-three elevations and the corresponding amounts of local relief were plotted on cross section paper. The pattern was such as to suggest a positive correlation (See Figure 5, p. 14). With such a trend there is justification for determining the regression equation for estimating the local relief given the local elevation. The next logical step consists of calculating confidence limits of expected local relief for any group of high points or any range of high points at the desired level of confidence, 90% for example. Plate No. 3 was developed from this relationship and value.

E. Dissection

Terrain units as defined are the result of dissected landscape. Given a unique geology and climate and a particular distance and elevation from base level, one might expect similar geometric forms to develop. In this study, terrain units are located by high points, and measurements of several random radii are averaged to determine the D-value. Slope is fairly constant falling in a relatively short range of variation; consequently, the geometric forms approach an inverted cone shape as the elongation number of the terrain unit exceeds one-half. The resulting measurements of terrain relief, "R", and average base radius, "D", should describe a set of right triangles with a variation

from actual similarity that is normally distributed. It follows that measurements of any sub set of components of the set of triangles should also be normally distributed. This was found to be true of local relief (See Figure 31, p. 82). When it was noted that the distribution of D-values was skewed to the right (Figure 33) i.e., some seemed to be much too large, an explanation was sought. In instances where the terrain unit extends out into a flat flood plain area the base of the imaginary triangle is extended disproportionately. The hypotenuse will no longer approximately coincide with the slope of the terrain unit.

Where raw data is not normally distributed it is common practice to apply some transformation which will result in a normal distribution. A logarithmic transformation provided such a distribution. The end points bounding 90% of the D-values were found and transformed back to the original data for mapping purposes (Plate No. 4).

F. Profile Area

Profile Area, A, is not an area. Rather it is an average of the several "A's" determined by the ratios of actual areas, "Ao's," of the terrain unit profiles to what might be called ideal areas, i.e., the products of respective "R's" and "D's". Where there is a net bulge upward, the resulting A value is greater than 0.5, and where the net bulge is downward the A value is less than 0.5. Figure 34 shows a clustering of values in the neighborhood of the 0.5 value. The upper and lower extremes are mapped on Plate No. 5.

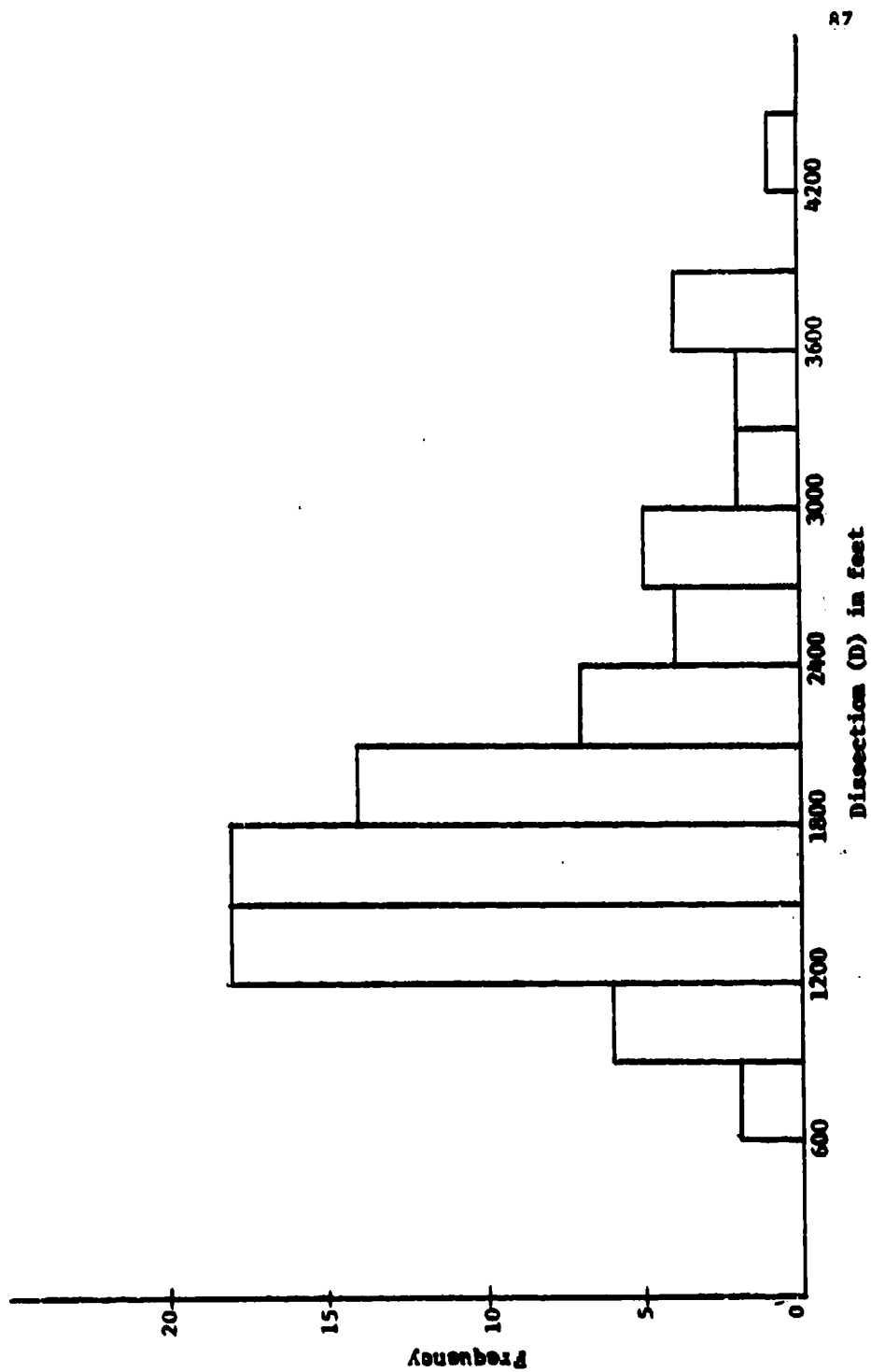


Figure 33. Frequency distribution of dissection.

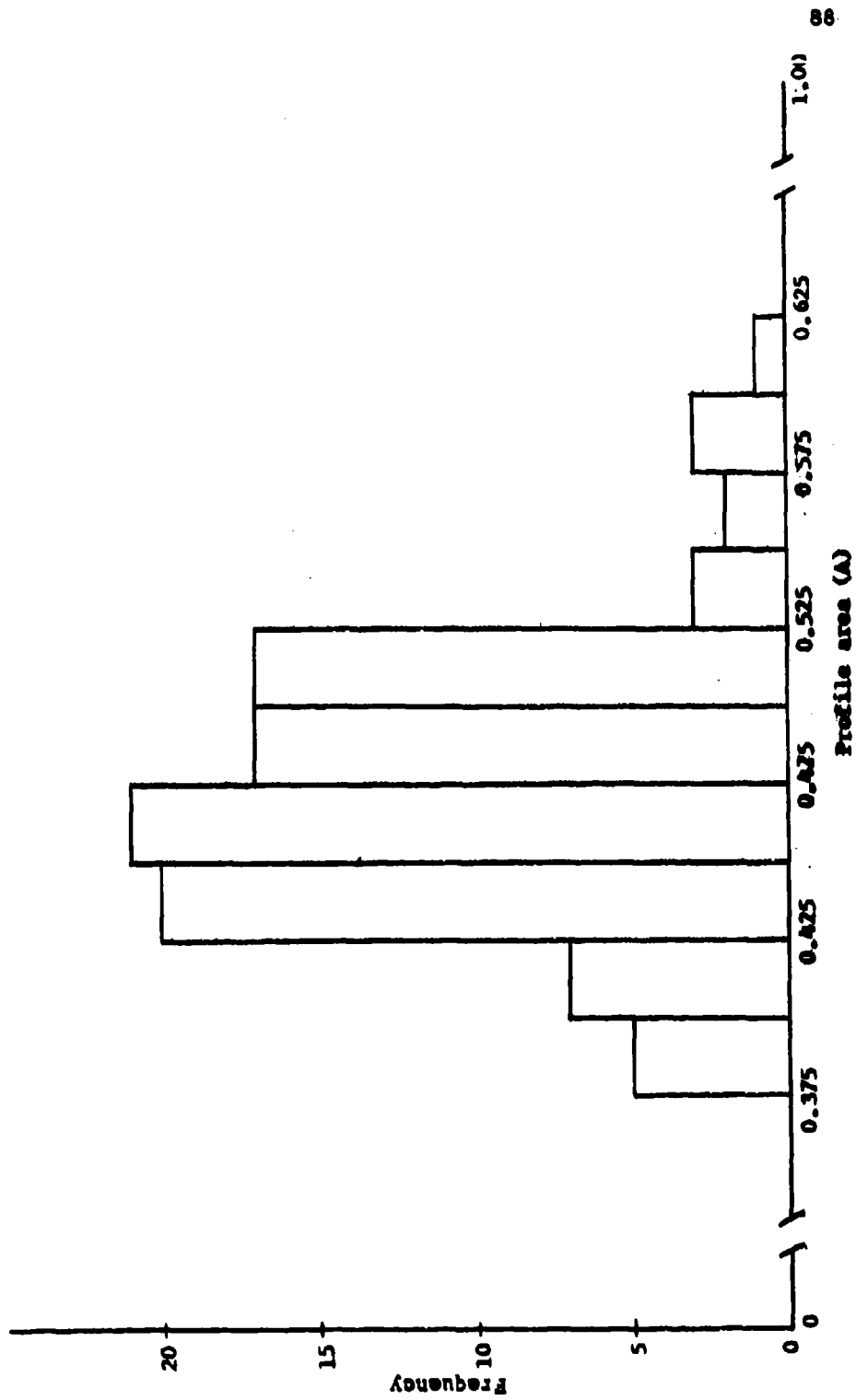


Figure 34. Frequency distribution of profile area.

The area beneath a profile (A_0) was determined using two different methods. Initially, profiles were plotted to scale on cross-section paper and A_0 was determined using a planimeter. This procedure was used to obtain A_0 values for a small number of terrain units on two quadrangle sheets. The trapezoidal rule method was used to obtain A_0 values for most of the terrain units. This latter method did save some time, but not on the order indicated by previous investigators.

G. Peakedness Index

The S value, (Plate No. 6) known as the peakedness index is an attempt to describe the characteristic tops of the terrain units. The procedure for obtaining S values is similar to that for determining the Q value except that only the top ten per cent of the terrain unit is considered. It is an attempt to consider the character of peaks of the terrain units; however, in as much as the method of determining S is similar to that for computing Q , somewhat similar weaknesses in results prevail. As measured in this study a low S value indicates a tendency toward flatness of the top of the terrain unit. All S values in this study lie below 0.5 (Figure 35).

H. Slope

The Q value (Plate 7) is the tangent of the average slope of the terrain unit, that is, Q is the quotient of average relief over average D for a given terrain unit. It is not surprising that the resulting distribution was found to be approximately normal (Figure 36), for the

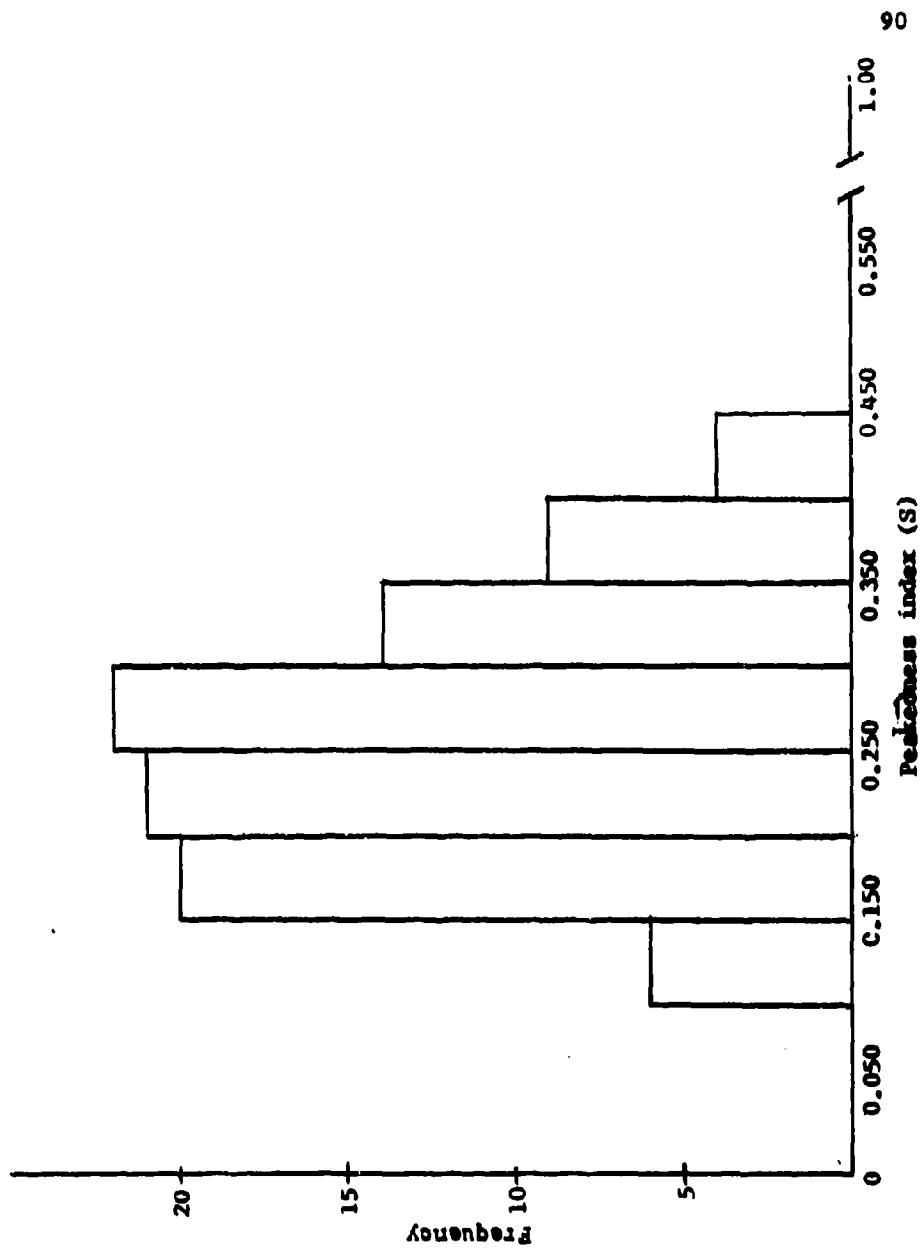


Figure 35. Frequency distribution of peakedness index.

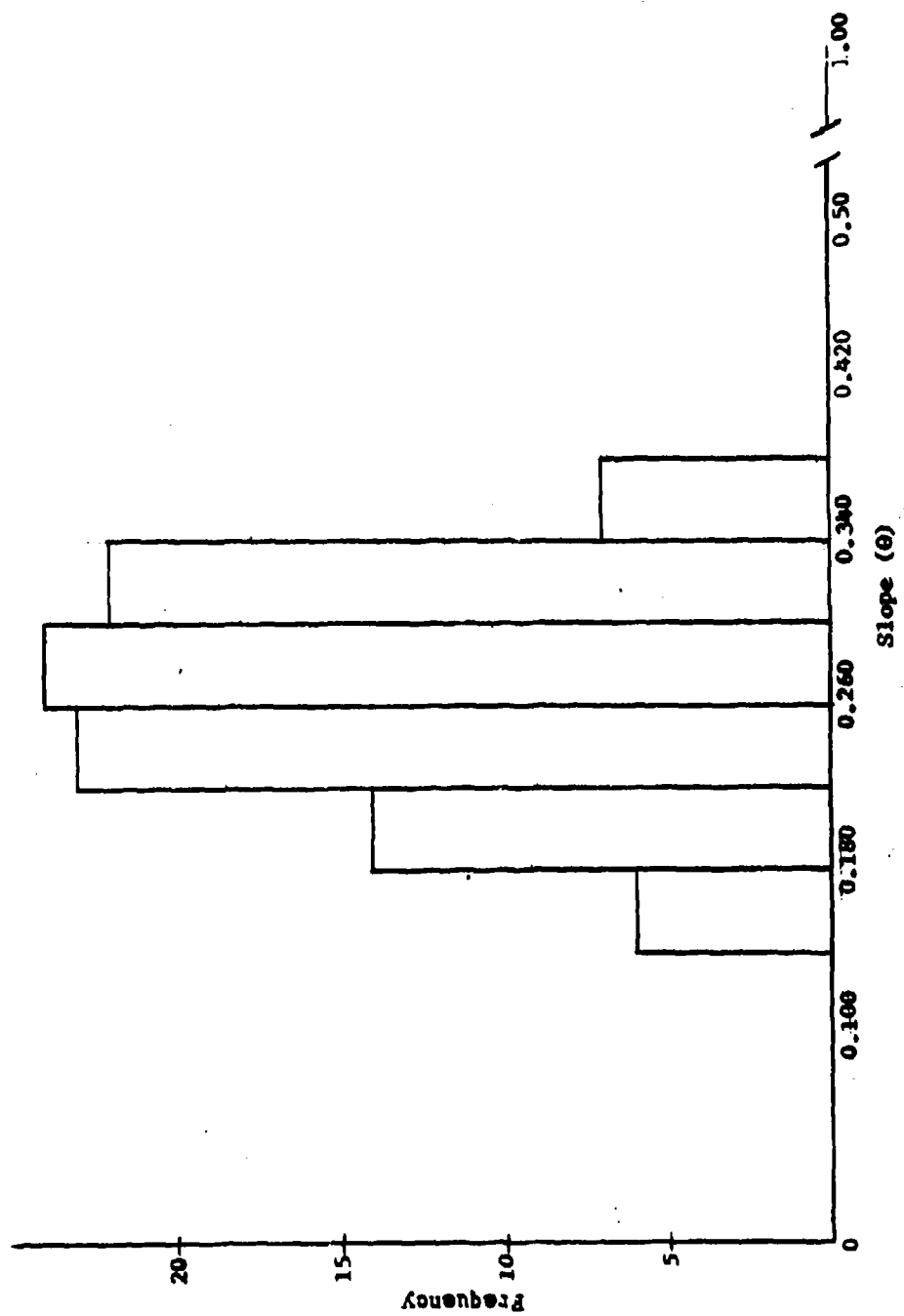


Figure 36. Frequency distribution of slope.

means derived from sets of related but not normally distributed data themselves tend to be normally distributed. Averaging the slopes around the unit tends to mask the uniqueness of the particular. Under such a procedure, units possessing one exceedingly steep side and one gentle side will likely yield the same descriptive θ value as a set of circular units with essentially the same slope on either side, neither steep nor gentle. Furthermore, if slope is defined as the angle of repose of weathered and unconsolidated material, then the measurements must be taken along the direction of the slope, and somewhere below the flattened top of the terrain unit and above the zone of accumulation at the base of the unit.

I. Parallelism Number

Parallelism refers to a description of the directional trend of the longest axes of the set of terrain units. These appear to be normally distributed except that the extreme deviations, i.e., those approaching a ninety degree deviation from the mean trend, occurred with too great a frequency (Figure 37). For the purpose of calculating the variance and standard deviation of the mean, several of the larger angles were re-distributed as their own back angles, e.g., an angle of 85 degrees may be represented as 95 degrees in the Cartesian or polar coordinate systems. Having determined these, it is a simple matter to determine the range of values into which future sample means will fall with a chosen level of confidence, in this instance 90%.

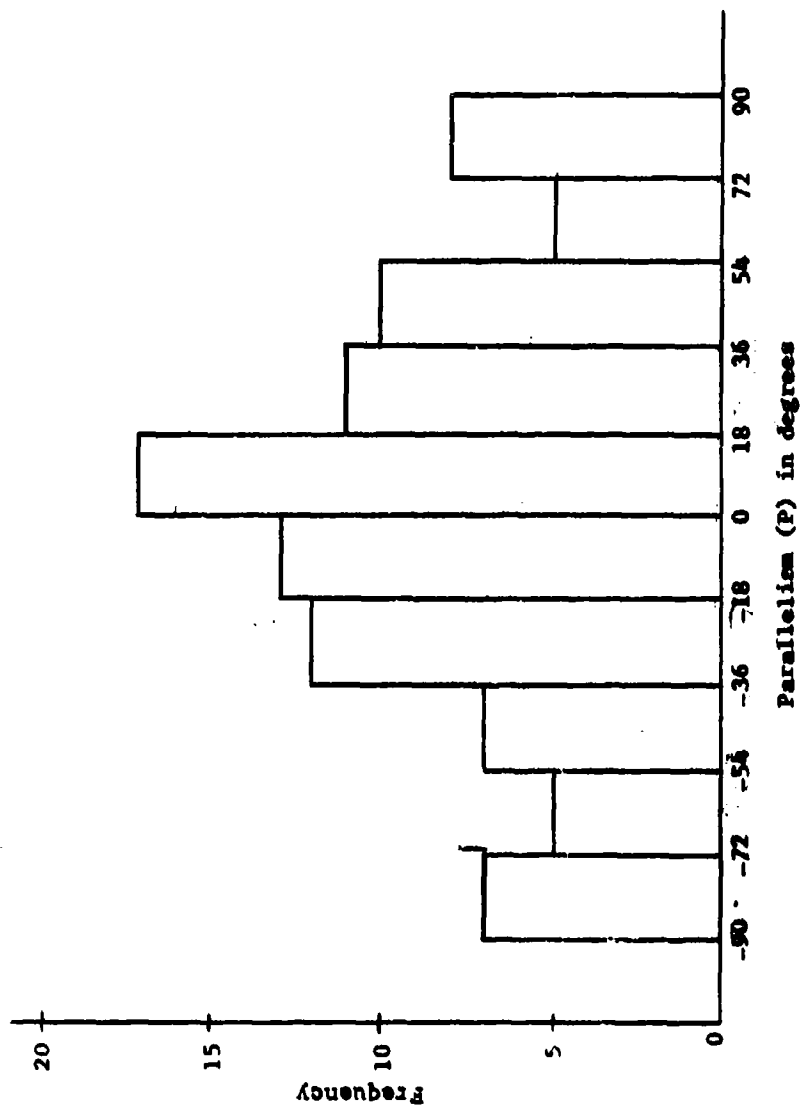


Figure 37. Frequency distribution of parallelism.

In situations where it is desirable to refer to parallelism by some scale, a conversion formula can be written. On the scale suggested here, absolute parallelism is equal to one, and no parallelism, that is, a right angle to the mean trend, is equal to zero (Plate No. 8). The formula used here is $P = \left| \frac{\alpha - (90^\circ - \beta)}{90^\circ} \right|$ where α is the positive clockwise angle of the long axis of the terrain unit from zero degrees north to 180 degrees south, and β is the mean direction of the sample of axes. β was calculated to be 2.37 degrees east of north with a standard deviation of 47.3 degrees.

Parallelism as defined here may be of doubtful military value if not completely misleading because the long axes of the terrain units, as they are defined, seem more often than not to approach a right angle to the general trend of the ridges and stream interfluves. Herein may lie the reason for the unexpected number of large deviations from the mean trend. Where the bounding sags roughly normal to the ridge or interfluve happen to be farther apart than the width of the ridge or interfluve, the long axis of the bounded terrain unit tends to shift approximately ninety degrees.

A means of graphically representing parallelism or the directional trend of terrain units or ridges on polar coordinate paper is suggested. This is accomplished by grouping the sample measurements in convenient intervals, ten, fifteen, or eighteen degrees for example, spread over a range of 180 degrees. The resulting graph or directional rose (Figure 38) gives a composite picture of all the represented trends which can be comprehended at a glance.

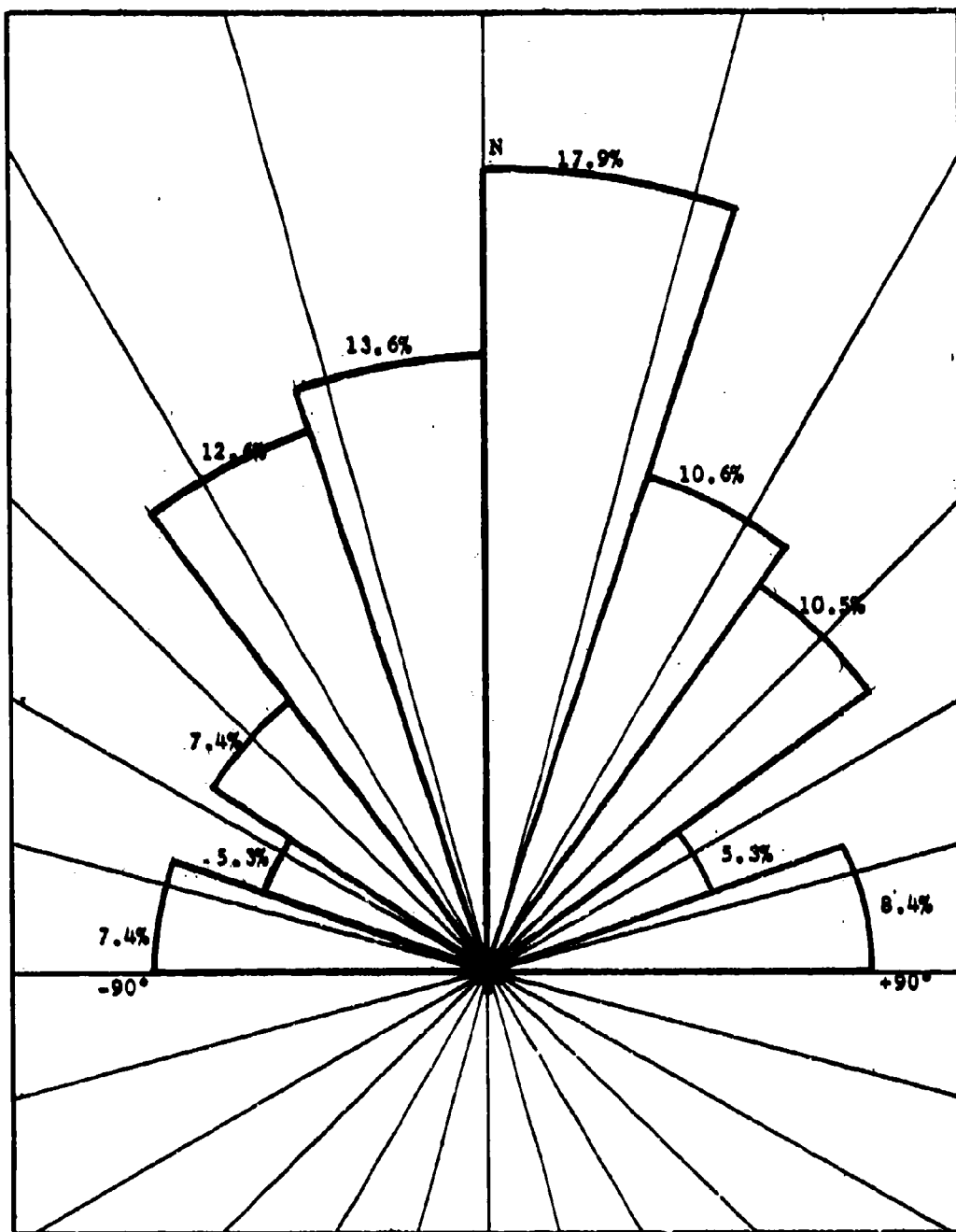


Figure 38. Directional rose for parallelism.

J. Summary

Whenever sampling methods are used for estimating parameters, i.e., characteristics of a given population, the problem of sample size arises. Obviously, the degree of precision must be decided upon. Once the precision, called the length of desired interval of confidence, is agreed upon, the next step is some consideration of the variation among the units of the population. This, of course, is usually unknown, but it may be estimated by drawing a small sample in advance. The formula is usually written as $n = t^2 s^2 / d^2$ where n is the sample size, s^2 is the sample variance, d is one-half of the acceptable interval of confidence, and t is a tabulated value for a given level of confidence. Nowhere does the size of the population enter the determination of a sample size. As the variance decreases so does the necessary sample size; as the acceptable confidence is increased n must decrease. In most instances a sample of 100-150 is quite adequate. This principle is amply illustrated in Figure 32, p. 84.

After a sample size is agreed upon and drawn, it is analysed to determine such things as the distribution, the mean, and the variance or standard deviation from the mean. The latter is not always possible where the data are not normally distributed. In some instances a mathematical transformation of the data will yield a normal distribution which permits analysis.

The investigator may be interested in the values lying within the confidence interval, those lying outside the C.I., or both. In

this study the values clustering about the mean tend to be emphasized by the nature of the bar graphs. The terrain units possessing extreme values and lying outside the C.I. were mapped on Plates 1-8, excepting Plate No. 3. From these one may obtain some idea of their size, shape, and distribution. More than 90% of the remaining units, those not actually drawn on the map, will fall in the 90% confidence interval.

IV. VEGETATION STUDY

A. Objectives

The major objectives of this portion of the work were

- (1) to study the physiognomic structure and organization of the vegetation clothing the terrain.
- (2) to record and report by means of the WES-standardized system of diagrams the variation in and among the kinds of plant communities present.
- (3) to construct a map showing insofar as feasible the variations within the vegetation, particularly as these might relate to military interests - especially that of the foot soldier.

B. Recent Vegetational History

Approximately 85 per cent of the area is covered by forest in a mosaic of varying stages of development and conditions. The non-forested portion consists of patches located mainly in the flatter bottoms along the principal streams, where the best sites are under active cultivation. Subsistence mountainside farms are rare and population density is relatively low. All of the area is in the Chattahoochee National Forest.

Because of the hilly character of the terrain, the forests are virtually all of uplands types. The higher mountainous communities fall

well within the Southern Appalachian section of the Oak-Chestnut Forest Region and the area south of Conner Mountain is included in the Oak-Pine Forest Region by Braun (1950).

In 1950-51 a forest inventory of the Georgia part of the Toccoa River watershed was conducted by the Division of Forestry Relations, Tennessee Valley Authority (Tennessee Valley Authority, 1952). At that time the forest area was composed of dominant forest types with areas as follows: upland hardwoods 66 per cent, cove hardwoods 10 per cent, yellow pines 9 per cent, yellow pine-hardwoods 8 per cent, white pine-hardwoods 5 per cent, others 2 per cent. Saw timber volume by major species groups included red oaks 35 per cent, white oaks 19 per cent, yellow poplar 13 per cent, white pine 10 per cent, chestnut 8 per cent, yellow pines 7 per cent, and others 8 per cent.

The area has been mainly included in a generalized oak-hickory type by Walker and Perkins (1958), and is rimmed by oak-pine on the lower uplands to the south of Conner Mountain.

Again in 1958, Fannin and Union Counties were surveyed by TVA as part of their continuing forest inventory study. The Ranger Training area, however, covers roughly only a half of these counties and therefore their statistical summaries (Tennessee Valley Authority, 1959, 1960) are not completely pertinent. Sample site locations and raw inventory data obtained from these samples have been made available by TVA for study and have provided a very limited source of accessory information.

Of the approximately 100 square miles under consideration, about two thirds is in private ownership. Much of it is quite steep and inaccessible by all-weather roads and thereby is better suited to forestation than to any other use. Consequently little of it has been clearcut for agricultural purposes; but varying degrees of selective cutting, much of it severe, have led to a wide range of conditions among the stands. At present, lumbering is very active in the region north of the Toccoa River, as for example, on Licklog Mountain.

C. Methods

1. Introduction

Introductory and familiarisation sessions were conducted in Knoxville by Waterways Experiment Station personnel at which time the Military Evaluation of Geographic Areas program in general was introduced, the structural cell concept was presented, and the current WES-modification of the Dansereau (1951b) life-form symbolic representation system was discussed in detail. The portrayal version as presented in the Waterways Experiment Station publication "Plan of Tests, Tropical Soil Studies," (Waterways Experiment Station, 1961) was accepted as basic reference and has been followed in the work to date.

A reconnaissance trip to the Ranger Training camp and its area of operations confirmed the expectation that the vegetation is mesic upland forest, characteristic of the Southern Appalachian Mountains, chiefly deciduous but with considerable local enrichment of evergreens. Yellow pines are common on exposed drier sites and white pine intermixed

with hemlock is abundant in the narrower moist valleys and lower north-facing slopes. Wet alder thickets are fairly common but there is nothing so clearly hydrophytic as a cypress swamp or sphagnum bog.

2. Data Forms

For purposes of field recording, a special tally form (Figure 39) was constructed and tested on several Knoxville area vegetation samples. This form is direct and brief and is likely to be best applicable only to the regional vegetation for which it was designed.

By means of the large block at top-right, kinds of plants requiring separate symbolization can be quickly codified with respect to height, woodiness, erectness, crown shape, stem diameter, leaf shape, leaf texture, and leaf size. Leaf class within a square of the large coding block is indicated by the position of a dot or check mark having reference to leaf character as indicated in the smaller four-square block. Beyond these eight parameters the column for "special features" provides a place for recording appropriate supplementary or clarifying information on characteristics having less frequent occurrence.

At first glance it may seem that even for temperate region upland vegetation this mode of classification is too gross. It is true, however, that in a complete list of plant variations, some parameters never interact - leaves can have size, shape, and texture only when present. Height of branching on an individual plant is either of horizontal or divergent type but not of both. In life, few if any non-twining herbaceous plants have leafy crowns in height classes six or seven, or stems in the

Elev. Slope (°) Toward Coordinates

- | | |
|--------------------|----------------------|
| 1
Needle | 2
Broad
hard |
| 3
Broad
med. | 4
Broad,
large |

-
- Height Class
- 8 Ft. 6
- 110 5
- 7 4
- 6 3
- 5 2
- 4 1
- 3 1
- 2 1
- 1 1
- 0.3
- 1
- Form Class
- 1 2 3 4 5
- Woody Non-Woody
- 1

[illegible]

Figure 39. Field data form.

larger diameter classes. The WES diagrammatic system depicts all crown shapes of erect nonwoody plants with an isosceles triangle differing only in its long axis.

Thus in the Dahlonga area, crown shapes of the woody species, especially those that contribute to the overstory, are predominantly of two fundamental types, round and pointed topped. Further, of these two shapes roundness is the more common. Elm and hackberry trees, notorious for their deliquescent habit and flatter tops when forest grown, are exceedingly rare within the area. The limited acres flat enough to support a swamp forest vegetation wherein these usually abound are typically under cultivation. Stem diameters on erect woody plants other than lianas tend to increase along with the increases in height, crown size and age. Correlation of diameter with height class in our area is close enough to justify its inclusion in the coding block, noting however, that some caution must be exercised. Height class seven trees must always be checked for one of two stem diameter classes, and taller members of height class six may occasionally have stems in diameter class four. Lianas are variable but tend to have small stems in relation to their height class, so stem diameters on these must also be checked individually. Herbaceous erect plants have no stems when represented symbolically, hence in reality no meaning need attach to the stem classes of the coding chart in the column for these plants.

Perhaps the greatest simplification has been possible with regard to leaf typing. Needle (or awl) shape coupled with broad-leafiness

typifies all of the tree leaves and nearly every important herb leaf-type except one, that of the grasses and sedges. It was with some chagrin that leaves at least five times longer than broad were so frequently rediscovered and were thereafter designated by a "G". Leaf textures turn out to be of only two kinds, by elimination. Except where galled, no thickened succulent leaves are present, and nothing thin enough to see newsprint through has been noted. Possible exception to the latter would be in certain mosses like Mnium, but here the leaves are routinely small (1-3 sq.mm.) and the plants provide low cover percentage. The great preponderance of leaves are of papery, flexible texture as are those of oak, hickory, sunflower, or Johnson-grass. In strong contrast, leaves of Rhododendron, laurel, and holly are notably harder, thicker, more stiff - they generally retain some deformation when tightly wound around a pencil, but seldom break. Pine needles were and are a problem, but all species in the study area have been judged rather arbitrarily to fall into the membranous or more flexible category rather than the stiffer inflexible group. Most leaves become flexible when wilted, and wilting itself is a highly variable character. Size of leaves presents little difficulty. The only really large leaved plants in the area are species of Magnolia and leaves on these are broad and flat with papery texture, thus constituting by themselves class number 4 in the leaf-classification block. Needle-like leaves, as pine and hemlock, having little or no flattened lamina were therefore judged to belong to the class meriting less than one square centimeter of area designation.

Other items on the field data form are standard and self explanatory, except perhaps the column for representative plants. While the WES system per se requires no other plant designations, our group was interested in this facet and has found the information of interest. Additional reference to this subject will be made later.

3. Choice of Sampling Areas

Aerial photographs were not available at the outset of the field work and early sampling sites were chosen on the basis of reference to one or more of the following criteria:

- a. Widely different plant associations were known to exist in the area but their diagrammatic representation with the present system was as yet unknown. Examples, white pine-hemlock, oak-hickory, or oak-pine.
- b. Differences within and among community types could be expected to occur due to wide variation in intensity of ecological factors operating. Topographic diversity was conspicuous.
- c. Locations on maps showed approximately two dozen randomly picked sample sites used by TVA in their 1958 inventory study. These samples, if they could be relocated and evaluated, might offer help by extrapolation.

Later on, one complete set and two partial sets of aerial photos became available and were studied at length. Before the field season ended, sites were being chosen to answer questions about vegetation in specific areas and to fill gaps in the series that finally emerged as vegetation mapping units.

These latter constituted a growing puzzle as the variety of diagrams in the various stands enlarged and no consistent trends seemed to develop. At the same time increasing familiarity with the Ranger program of training activities tended to add weight to a short but significant list of relationships. It is because these finally became factors in later efforts to document and map the vegetation that they are mentioned here as follows:

- a. Rangers proceed without dependence on wheeled vehicles hence large stems in almost any common density can be avoided if they are upright and if their lower branches are not persistent, but a thicket of smaller stems with abundant branching can approach the "no go" condition.
- b. Much of their movement occurs at night without supplementary light, thus intensifying the problem (or danger, as to the eyes) of any impedence, as for example, that of deadfall and foot-entangling vines.
- c. They must avoid detection from the air in daytime; therefore, per cent of crown cover and its height become critically important.
- d. Patrols proceed on predetermined compass courses and tend to endure or overcome annoyance rather than risk loss of time or proper heading by attempts at uncertain circumvention. This tends to increase rather than minimize possible exposure to thorns, poison ivy, stinging nettles and probably snakes.

4. Sampling Procedure

The initial method of choice was to employ circular, nested, variable radius plots, experience having demonstrated that these can be highly productive of information with minimum investment of time and labor. For the kinds of information usually sought by plant ecologists and foresters on relationships among the dominant individuals - a single 100-foot diameter sample in homogeneous forest vegetation in the study area will provide relatively reliable data of a reconnaissance type. Usually, however, a series of samples employing somewhat smaller diameters would be used to establish the "point of diminishing returns," as with a species-area curve, when critical or detailed data on a stand of less homogeneous vegetation is desired.

Cain (1935), reporting on basal area studies in fir forests of the higher Smokies, found that 30 quadrats 50 square meters in size constituted a satisfactory sample of the trees of the association. Oosting (1948) indicates six to be the minimum number of 10x10M quadrats necessary for sampling the tree strata in oak-hickory forests on the Piedmont in North Carolina.

The WES system of notation while ostensibly not recognizing plant species as such is directly based upon the structural differences among species and will occasionally differentiate between some of the members in a sample at the species level. Mostly, however, it tends to lump species.

In sampling practice, therefore, to be qualitatively representative of an area a plot need only be big enough to include those kinds of

species in the area which the system is able to differentiate, but not necessarily all of the kinds of species that might be present. On such a basis a kind of indicator or "partial flora" species-to-area relationship exists.

A more practical point of interest however attaches to all of the accessory species - those in addition to the species which first necessitate each kind of structural symbol to appear in a diagram. Kinds of species may grow alone or side by side affecting each other. Tendency of individuals within a species toward clumping in some degree is a very common character and is difficult to measure, yet each individual plant adds its own stem and portion of cover to the whole. Each species adds characteristics not at all sorted by the system. Their fruits (for example) are various in color, size, frequency, odor, and palatability to man. They also strongly influence the distribution of animals in both number and kind. It is the total combination of kinds of elements coupled with their frequency that really constitutes the uniqueness of a sample. A kind of structural element in North Georgia may represent five species of plants within one sample. The same kind of symbol might or might not represent five species of plants in a sample taken in Vermont, but it is virtually certain that the species would be different. Thus the two symbols are interchangeable in the sample diagrams but they really refer to two separate clusters of plant capabilities and characteristics. Each group is successful in its own plant-association, the groups may occupy equivalent niches, but the plants would likely die if transplanted. Thus in any given area

sample size probably should be equal or greater than species-minimal area size in order to most validly portray the sum total of the vegetation.

In the field, visual inspection was employed to locate each sample within what appeared to be a fair representation of the local degree of homogeneity with respect to the dominant plants. A large individual of the least frequent but characteristically present dominants was chosen as the center of 100 ft. diameter circles in the earlier forest samples. Within these, a smaller circle of 20 to 40 ft. diameter was used for sampling the low-growing plants of height classes one to three, and the whole area was used for the taller height classes. It was realized that even with this method of two sizes of samples over-sampling was bound to occur for some abundant kinds of plants, just as under-sampling would always occur with the rarer kinds. However, on the basis of previous experience in similar vegetation it was known that the 100 ft. circle could be expected to give generally reliable information with height classes six and seven trees, and it was felt that any extra effort spent in over-sampling might not be entirely wasted. For comparative purposes it would be an advantage to have samples of a single size, and certainly the relations of values in the 100 ft. diameter circle make for easy and rapid field calculations. The coverage of any element may be determined directly from: $\frac{\sum(\text{diameter}^2/100)}{\text{per cent coverage}}$ of the sample. Later, with sample size derived by computation of a "plateau" diameter based on mean area of a certain dominant structural

element, the structural cells were in each case measured 100 ft. or smaller in diameter. In these no subsampling was done for determination of frequency and cover percentage in the lower height classes.

At the outset it was hoped that precise plane table maps of all overstory crowns could be drawn and correlations of stem size and distribution would be attempted. The size of the total operation on the area assigned turned out to be much larger than anticipated so individual crown covers were lumped together and reported by structural elements only. Stem frequency data by size classes were taken on only about half of the samples.

No collection of voucher specimens was made.

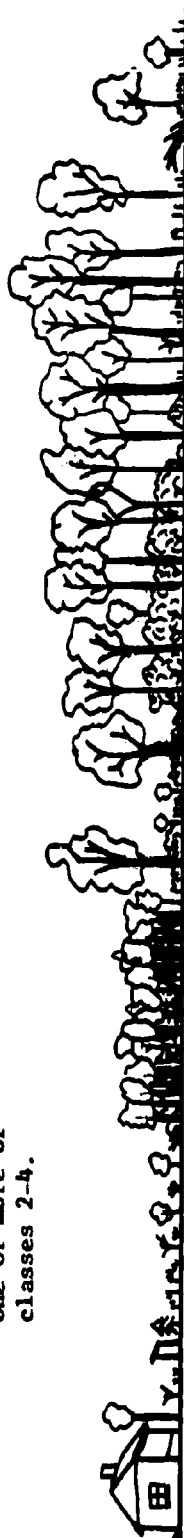
5. Mapping

In the development of the vegetation map, principal reference was made to the available aerial photographs. The north half of the area was almost covered by a series with good overlap taken in early November of 1960 with scale at 1:15000. On these the leaves were still in evidence. Another partial coverage set with less overlap taken in mid December of 1955 with scale of 1:20000 covered approximately the southern half of the area - except for one completely missing strip. The one complete set for the whole area was of January, February and March, 1954 vintage with 60 per cent overlap and scale at 1:20000. On both of these last two sets no leaves were discernible in the deciduous crowns and in numerous areas cutting had by now changed the landscape markedly.

The major problem was to fit together somehow the fine scale detail of a limited number of ground samples with the relatively large scale photographs. More precisely stated, in what way might approximately 100 square miles of hilly forest land be characterized with the existing photographic information supplemented by the detail of less than a .002% ground sample? It was immediately clear that only the grossest information could be used by extrapolation from the ground samples to the aerial photographs. For example, height, density of crown cover, and, in some cases, stem frequency could be estimated for the taller height classes. Photos of stands at different seasons of the year would help delimit evergreens and be especially useful in spotting the laurel under deciduous canopies. Where it occurred under pines and hemlocks it would be difficult if indeed possible to recognize.

It was in recognition of this problem that special cognizance of the activities of military personnel was made and the series of mapping units depicted in Figure 40 was selected. It will be seen at once that these attempt to deal practically with large clusters of plant characteristics more or less in toto. Involved directly as life-form characteristics are height, crown cover per cent, stem frequency, stem branching, woodiness, tendency toward twining, spine and poison production. Other characteristics, as reproductive potential, degree of association, specificity of ecological niches, and rate of decay are definitely though perhaps less obviously expressed. Much more clear is the over-riding influence of man - upon whose activity in the area five of the seven categories are based.

<u>Presently Cultured</u>	<u>Old Fields</u>	<u>Thicket</u>	<u>Park - Woodland</u>	<u>Forest with Thicket</u>	<u>Forest - No Thicket</u>	<u>Slash</u>
	Not over 20% closure in tallest ht. class; may be complete in one or more of classes 2-4.	Up to 100% closure in ht. classes 5, 6	20-60% cover in high (class 7-8) layers	60-100% closed overstory and 30-100% in ht. classes 3-5	60-100% closed overstory	Variable cover, averages 50% in ht. class 6 or above



Buildings	Weedy mixture of low and often rough herbs, decumbents and seedling trees; branching sawbriars, blackberries and poison ivy are common	Dense mixture of small-stemmed trees with very low and profuse cover	Scattered tall trees, a few shrubs, good ground cover. Usually pastured	Mixture of tree sizes, with dense-branched "laurel" (includes Rhododendron, Kalmia and Leucothoe alone or together)	Mixture of tree sizes, and small trees a few shrubs, remaining; but not blackberries, poison ivy, sawbriars, brush piles, are common. Snake country.	Cut-over; culls
Grounds						
Gardens						
Row crops						
Meadows						
Open pastures						
Poor-variable cover; good footage; People and dogs common	May have good horizontal cover; poor to no vertical cover; often tangled underfootage; thorny	Good cover; slow and difficult passage	Poor cover; fast passage	Excellent cover; tedious passage by crawling	Excellent cover; generally easy passage	Doubtful cover; passage can be slow and hazardous; fire potential high

Figure 40. Mapping Units (Dahlonge Area).

After finally deciding upon mapping units the aerial photos were interpreted and boundary tracings were made on clear plastic overlays. These tracings (after correction from field data in numerous cases) were then transferred to maps specially prepared to fit the two scale sizes of the photos. The two partial maps resulting were then reduced photographically to a scale of 1:25000 and assembled into a composite.

D. Results

Sixty-nine circular sample plots of nested variable radius type were selected and detailed observations were recorded in the field. Plots were located in areas chosen for their inclusion of different kinds of forest vegetation (as for example oak-pine, oak-chestnut, hemlock-white pine-hardwoods), in areas where differences were fully expected because of ecological factors operating, and from areas readily discernible on aerial photographs as owing their differences primarily to man's occupancy and activities. By choice effort was made to locate and sample as many representative kinds of vegetation as possible, and to that extent the data are definitely biased. Location of sample plots by number is shown on Plate 10.

Plot samples ranged in size from ten to one hundred feet in diameter and their distribution by sizes is shown in Figure 41. All of the ten and twenty-foot diameter plots and half of the thirty-foot plots were samples from old fields or thickets where vegetation is low or dense and tends to be rather uniform.

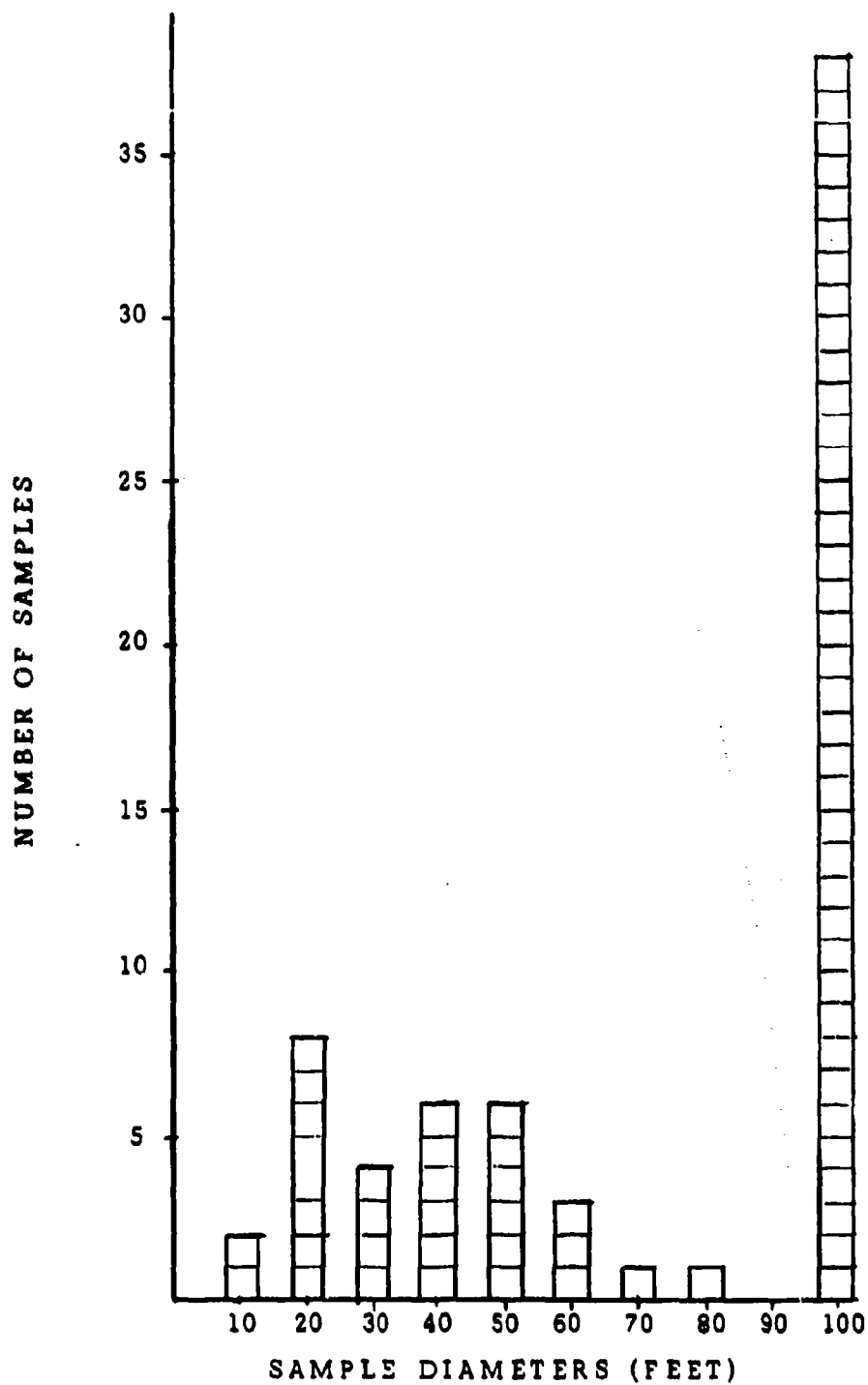


Figure 41
DISTRIBUTION OF SAMPLE PLOT DIAMETERS

A little more than half of the samples were of the maximum hundred foot diameter. All of these were in tall vegetation - forest, forest with thicket understory, or slashed forest.

Vegetation diagrams for all samples have been constructed according to the WES life-form system, and several complete sets are submitted under separate cover, together with one copy of each of the original field tally forms. Figures 42-47 consist of a set of diagrams of the vegetation of six sample plots illustrating the six generalized classes of vegetation used as mapping types.

General variation in degree of complexity of the vegetation is illustrated in Figure 48 where it may be seen that the extreme range in number of kinds of structural elements per sample extends from five to thirty. The median is at 14, and 75 per cent of the samples have from 10 to 20 elements each. It is implied that some of the plots of vegetation are several times as complicated as others.

The somewhat irregular outline of the curve of Figure 48 results from the facts that (a) different classes of vegetation owe their differences in part to the number and degree of development of the component structural elements and (b) uneven numbers of samples were obtained within given classes of vegetation. In all, thirteen samples were from old fields, three from thickets, two from park-woodland, seven from forests with thicket, thirty-five from forests (without thicket), and nine were from slash. In Figure 49 the individual samples of the previous figure are designated as they relate to the series of mapping types and the arrows indicate positions of medians.

72

VEGETATION STRUCTURAL DIAGRAM

LOCATION 51

DATE 7/30/62

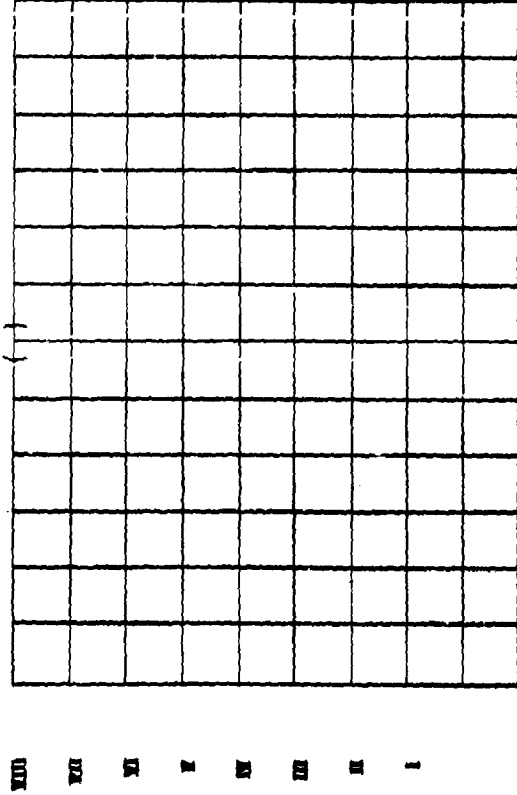
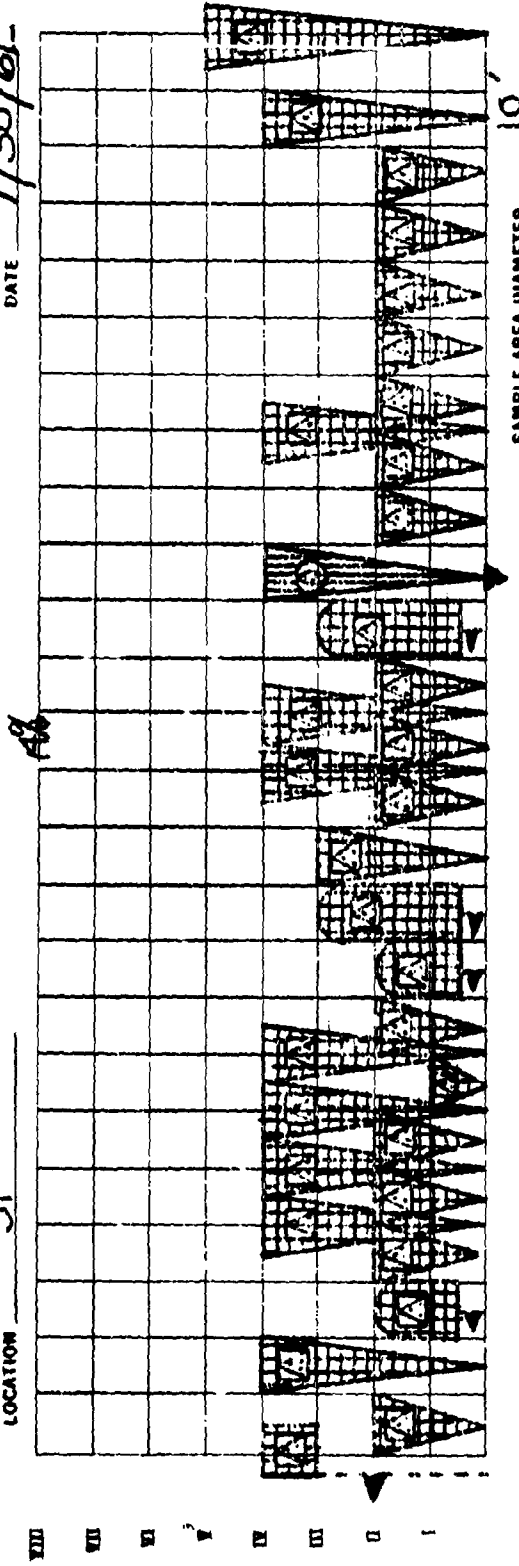


Figure 42. Old field vegetation in former corn field.

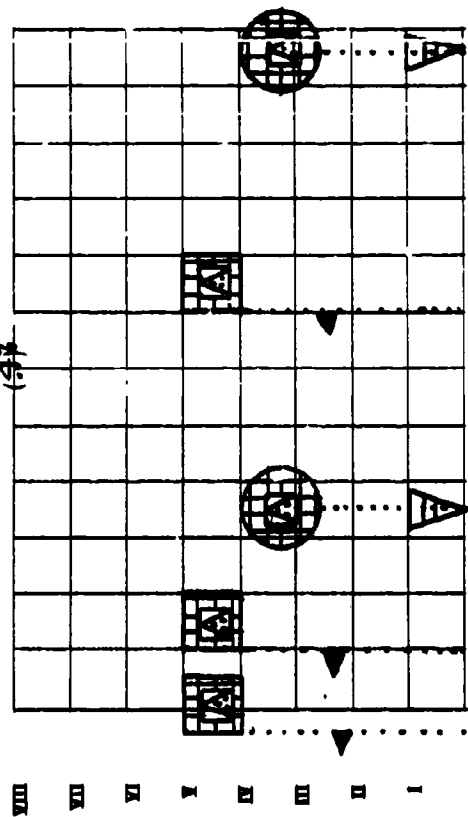
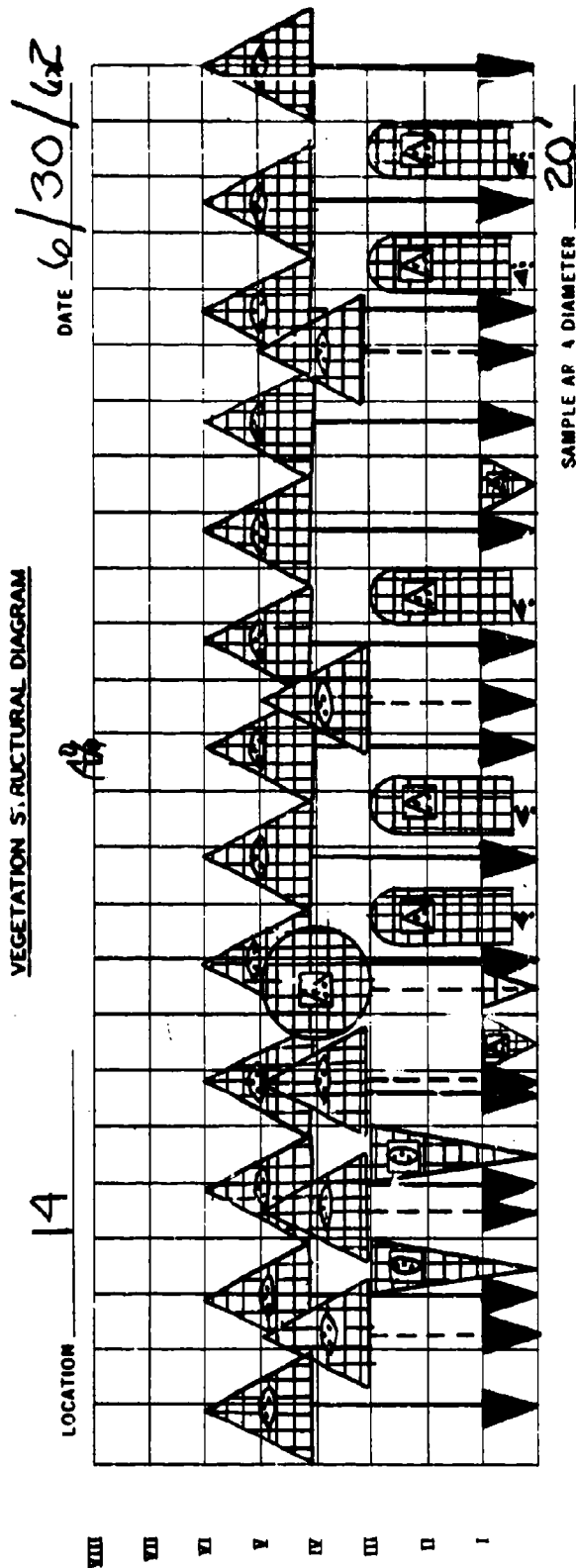


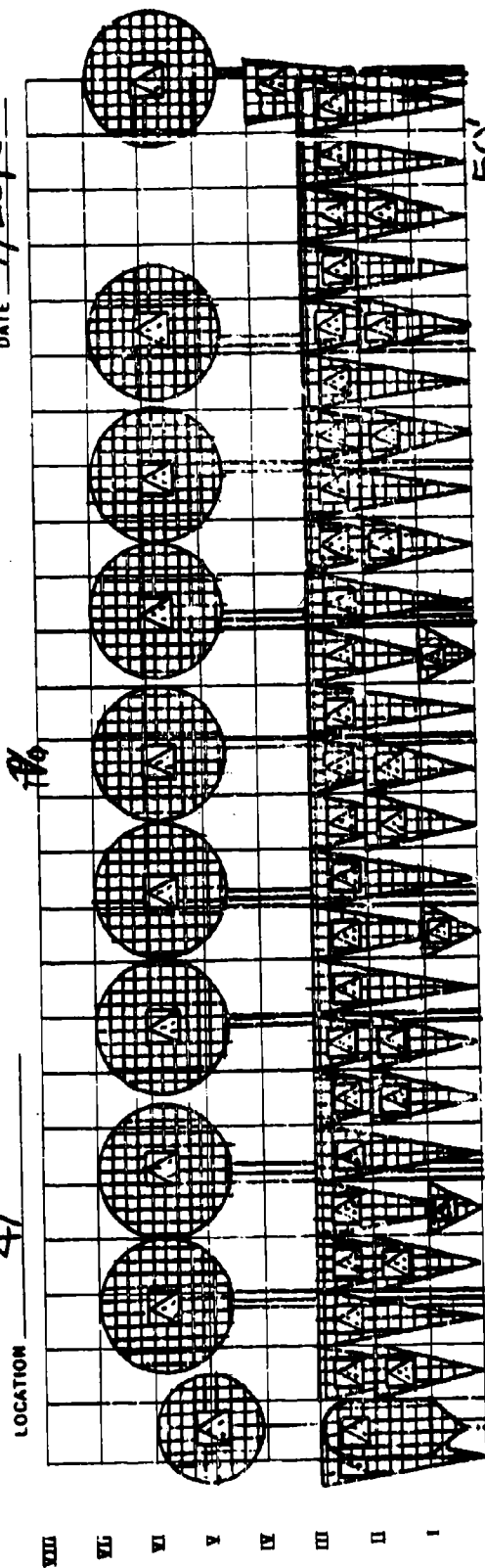
Figure 43. A pine thicket.

VEGETATION STRUCTURAL DIAGRAM

LOCATION 47

DATE

7/23/62



$$0.6\sqrt{Am} = 10.04$$

SAMPLE AREA DIAMETER

50'

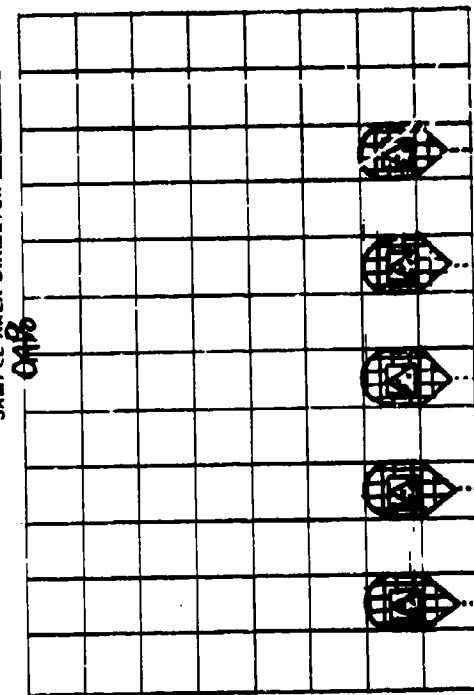
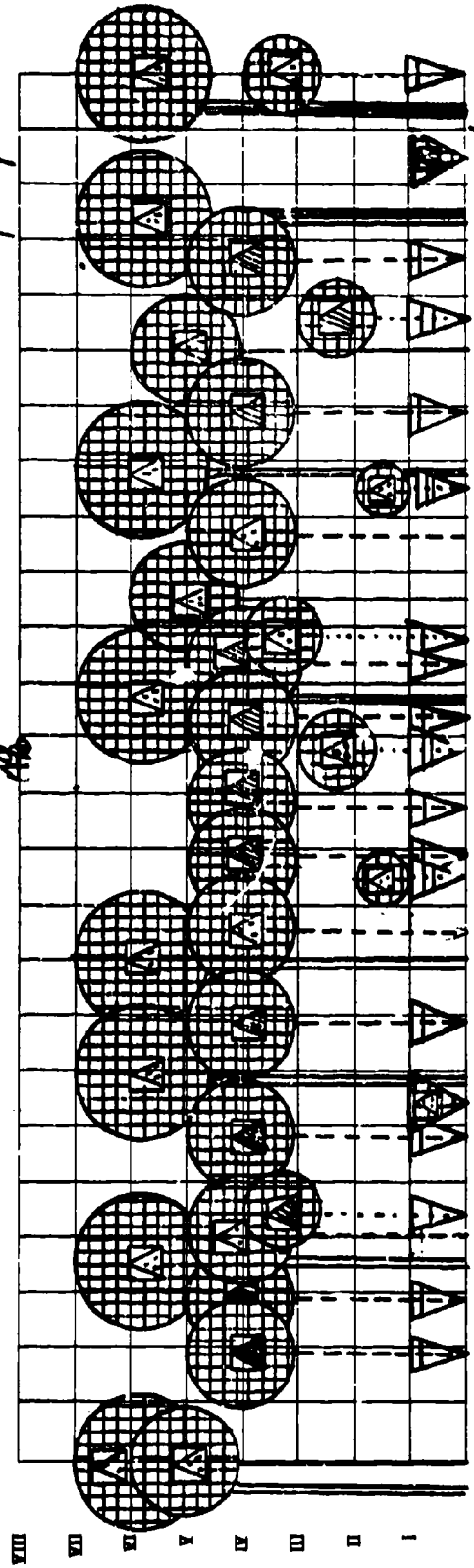


Figure 44. Park-woodland.

VEGETATION STRUCTURAL DIAGRAM

LOCATION 35

DATE 7/12/62



SAMPLE AREA DIAMETER 60

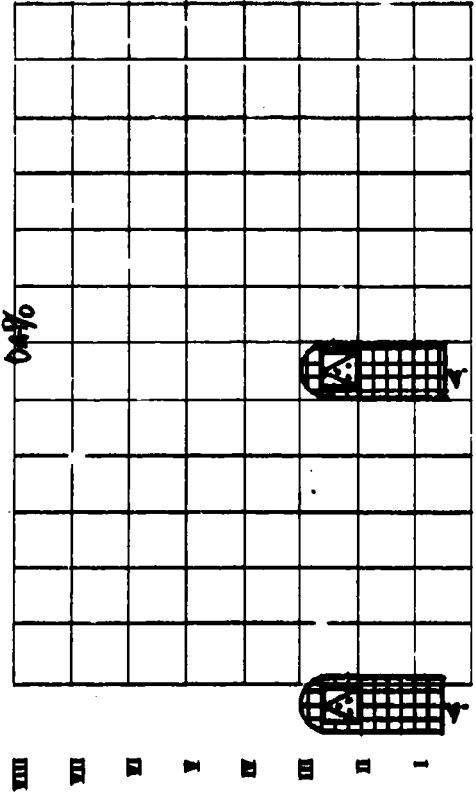


Figure 45. Forest with laurel thickets beneath.

VEGETATION STRUCTURAL DIAGRAM

DATE 6/29/62

LOCATION 12

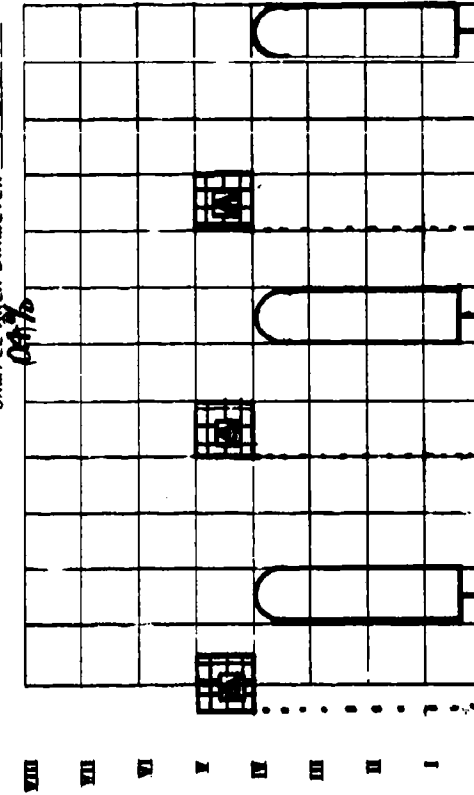
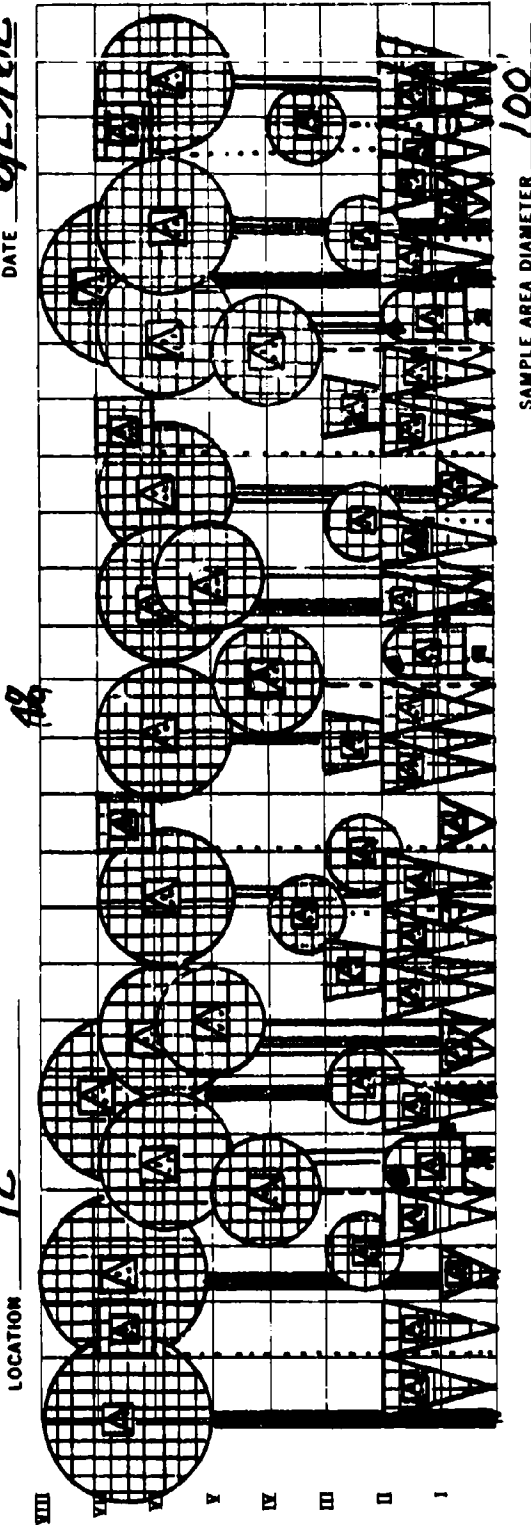


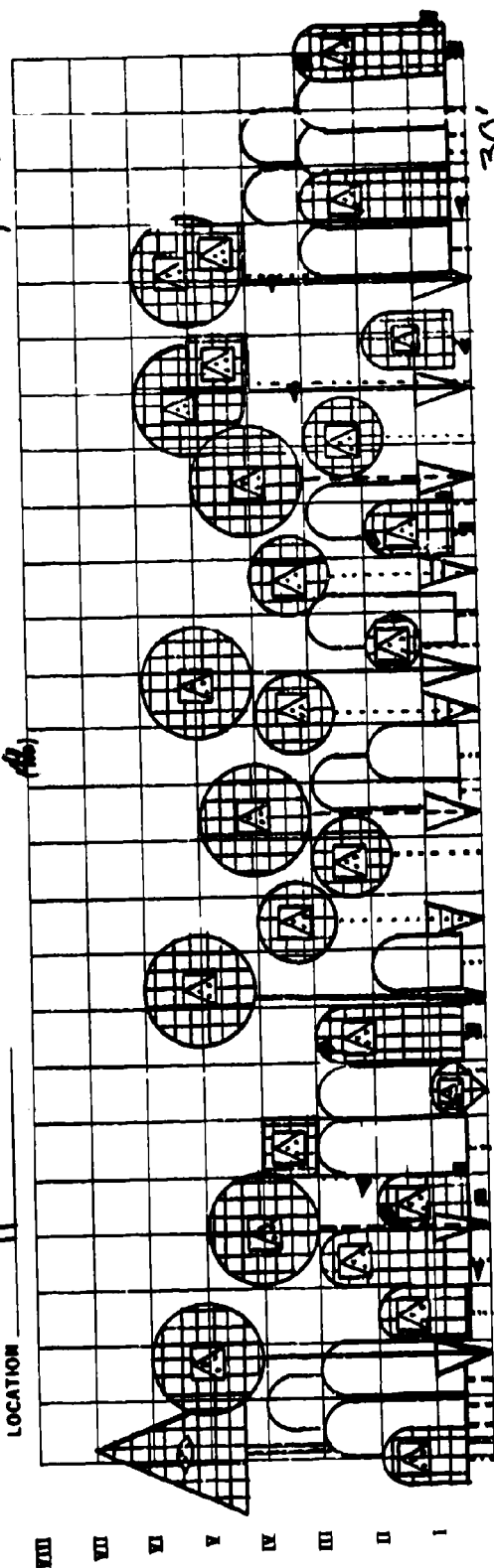
Figure 46. Forest on north-facing slope of Conner Mountain.

100' 0475

VEGETATION STRUCTURAL DIAGRAM

DATE 7/21/62

LOCATION 41



$$0.6\sqrt{Am} = 5.04$$

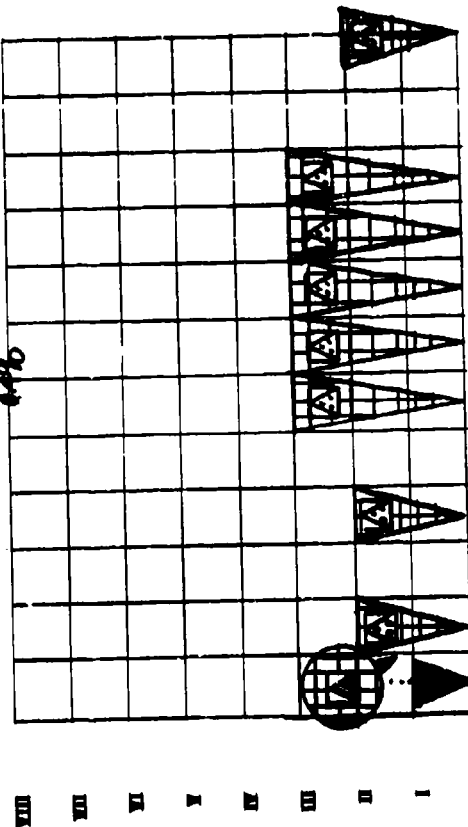


Figure 47. Slashed forest.

PLOTS

8
6
4
2

T PW OF F FT S
↓ ↓ ↓ ↓ ↓ ↓

5 10 15 20 25 30

STRUCTURAL ELEMENTS

Mapping Types

- F - Forest
FT - Forest with Thicket
OF - Old Field
PW - Park-Woodland
S - Slash
T - Thicket

Although very few samples were collected in thicket and park-woodland and the information is therefore only suggestive, the very fact that their cover occurs in a restricted number of height classes would appear to be compatible with their lower number of structural elements as recorded in the field. Old field vegetation is more complicated, and while its range in elements is nearly that of the range of forest elements its median is clearly lower. The name slash is here used for stands (formerly forest) in which relatively recent cutting has opened conspicuous areas in the overstory and notable amounts of tops and limbs remain in undecayed condition on the forest floor. This also is apparently a complex type although its range of elements in these samples is narrower than that of the forest.

Distribution of the six vegetation categories together with land presently cultured is shown on a scale of 1:25000 on Plate 9. It should be noted that boundary delineation is inherently easier between some of the types than others. Distinctions, as with slash, have sometimes been arbitrary - although there is probably no virgin forest in the whole area. Most difficult of all to delimit was forest having the laurel thicket below. In cases where it occurs under hardwoods it may become visible from above in winter. Sometimes, however, the laurel is associated with hemlock and white or other pines and is thus obscured from aerial observation at all seasons. On photos as ours with scales at 1:15000 and 1:20000, prints of uniformly good quality are highly essential, and the accuracy of our map remains to be tested.

E. Analysis and Discussion

It appears without a doubt that a wide spectrum of life-forms can be successfully portrayed by the diagrammatic system in its present form. Yardstick of success in this case being the retrieval of the information by the reader of the diagram.

Figures 50 and 51 are diagrams of samples taken within 700 feet of each other and are illustrative of the considerable differences in vegetation due to local site influences. The plot with the taller, more dense overstory was part of a deciduous stand in a steep "moist and protected" ravine, while the other was from an oak-pine stand on a much less steep but "dry and exposed" lead. Both were at approximately mid-altitude on the broad south-facing slope of a major ridge, Conner Mountain.

Figure 52 is illustrative of the vegetation at the summit of the ridge. Here the forest is relatively open and is composed of scattered oaks with an abundance of herbs in low height classes. Woody seedlings and saplings so characteristic of actively reproducing forests are in short supply. In some cases these ridge top stands have stagnated so extensively that sufficient light penetrates to support a growth of numerous grasses and a wave of woody reproduction. Such condition is shown in Figure 53.

By way of contrast a sample taken high on the moist north-facing slope of the same ridge is represented in Figure 46, page 120. This well stocked mature stand shows not only a very dense overstory

VEGETATION STRUCTURAL DIAGRAM

DATE 6/27/62

LOCATION 2

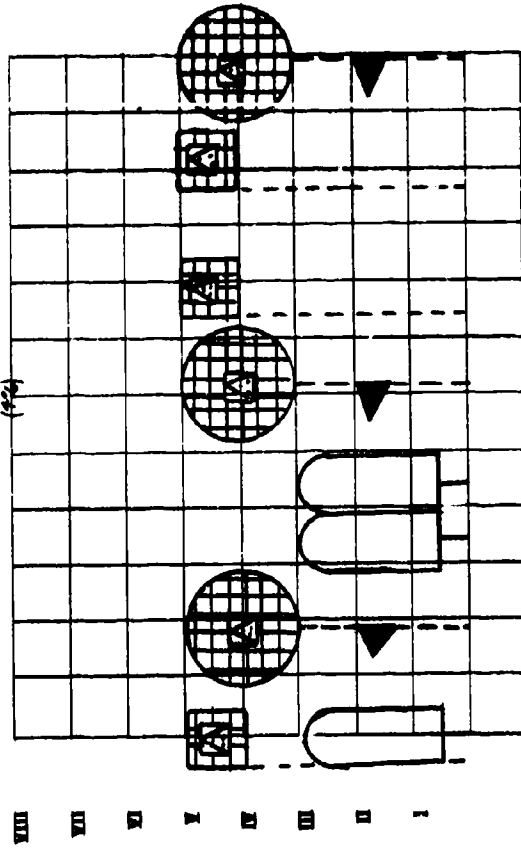
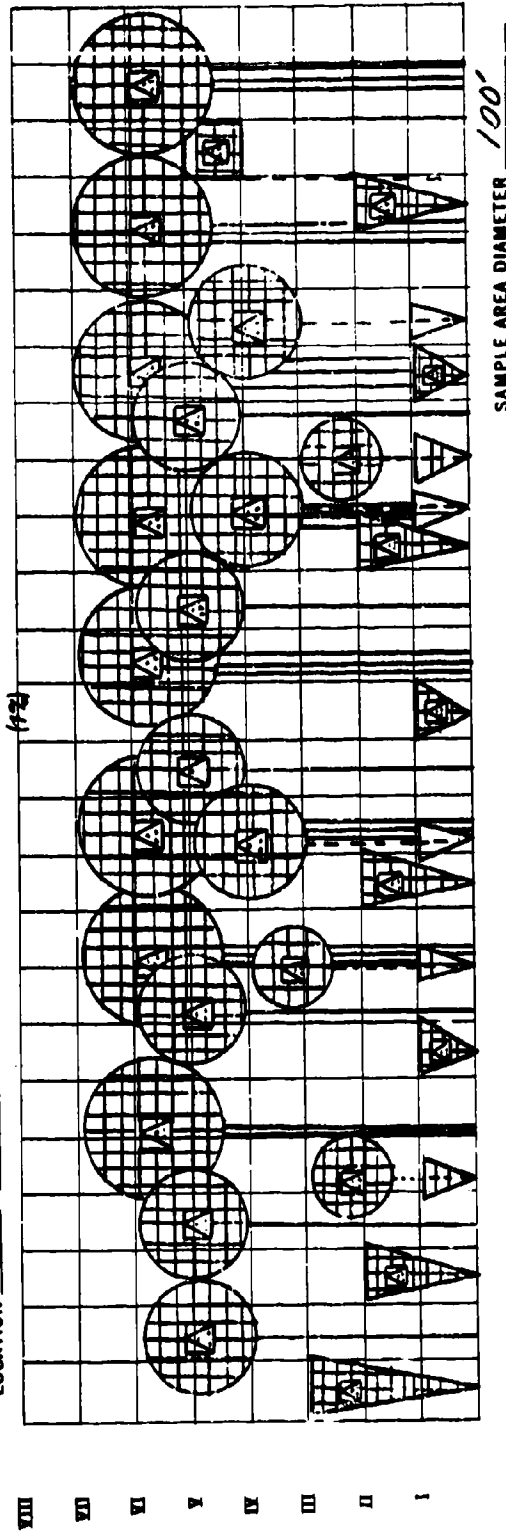


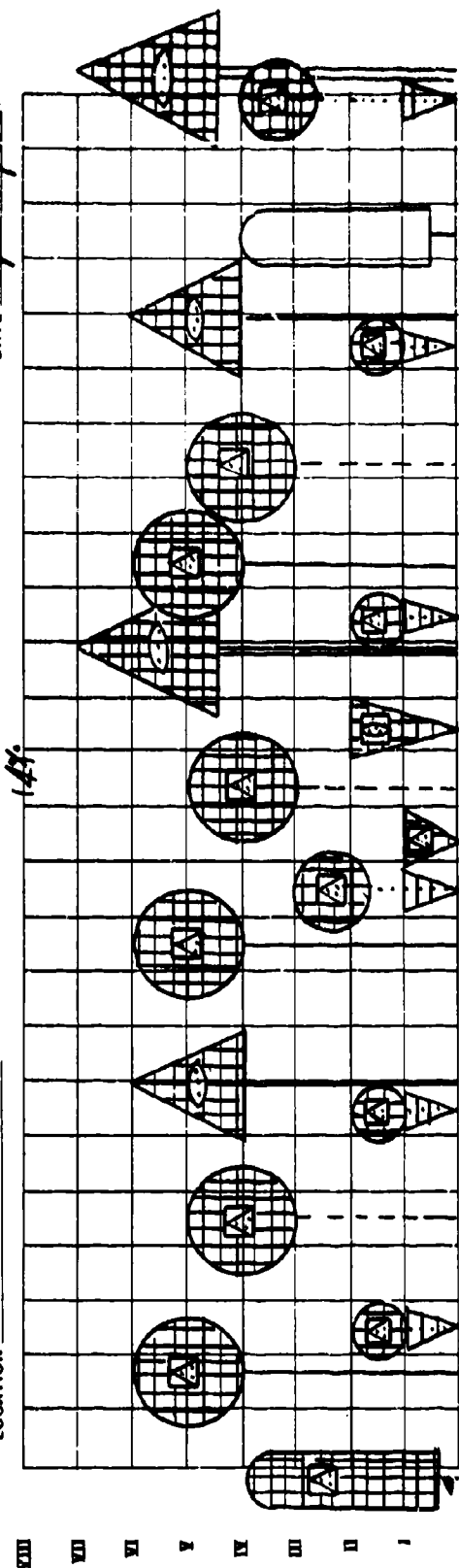
Figure 50. Forest in Moist Ravine

VEGETATION STRUCTURAL DIAGRAM

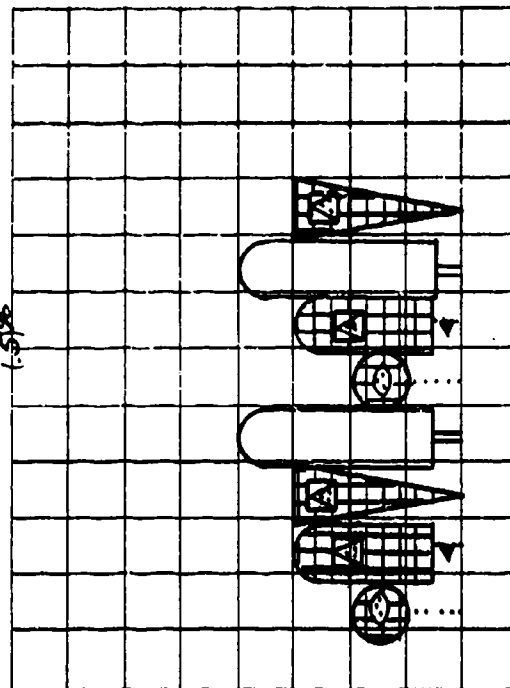
DATE 6/27/62

3

LOCATION



SAMPLE AREA DIAMETER 100
1.51%



VIII
VII
VI
V
IV
III
II
I

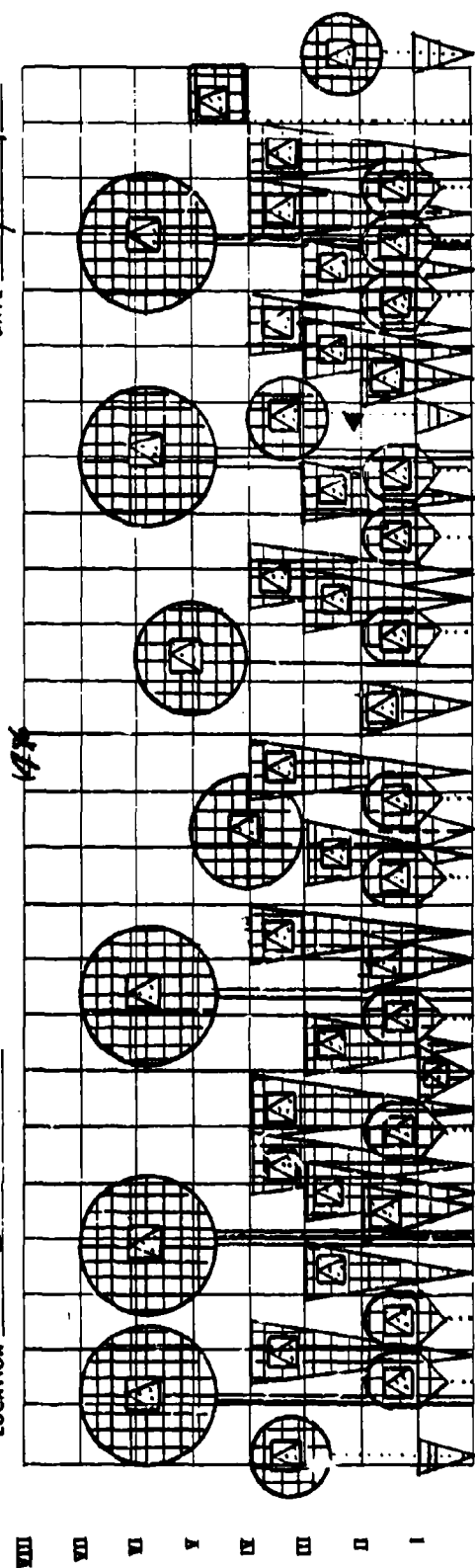
Figure 51. Forest on Exposed Slope

126

VEGETATION STRUCTURAL DIAGRAM

DATE 6/28/62

LOCATION 8



VIII
VII
VI
V
IV
III
II
I

Figure 52. Forest on summit of a ridge.

127



Figure 53. Ridgetop with abundant woody reproduction.

(148 per cent in height classes seven and eight) supported by stems of varying cross section, but also good woody reproduction and an abundant herbaceous ground cover. The sample has more height class eight trees than is typical of most forests of the training area, but is otherwise a fair representative of differences typifying north and south-facing slopes. Temperature and moisture regimes are markedly different.

It is not always easy to determine the cutting history or the burning record, but signs of cutting within recent years were not present in these particular samples. The Ranger training area, however, does include much land in private ownership, and selective cutting, some of it severe, has been widely practiced. Thus the condition of most forest stands is often more clearly related to the modifying effects of man's use (or neglect) than to the processes of uninhibited natural succession. In these forests high percentages of cover can occur in any other (but not all, in concert) height class along with that of the overstory itself. Figure 54 shows by means of star diagrams the cover distribution in two samples of forest (one of which has been previously mentioned and is diagrammed in Figure 46, p. 120). Here eight radii correspond to the eight height classes and each millimeter of length along a radius equals one per cent of cover in that particular stratum. The boundary subtending the radii is not interpreted here to have specific quantitative meaning other than as it tends to emphasize general size and shape of the figure. The shape, in fact, is quite diagnostic. Forests by definition have high cover percentages in upper layers. Plot thirteen of the same figure was in a selectively cutover area of forest having

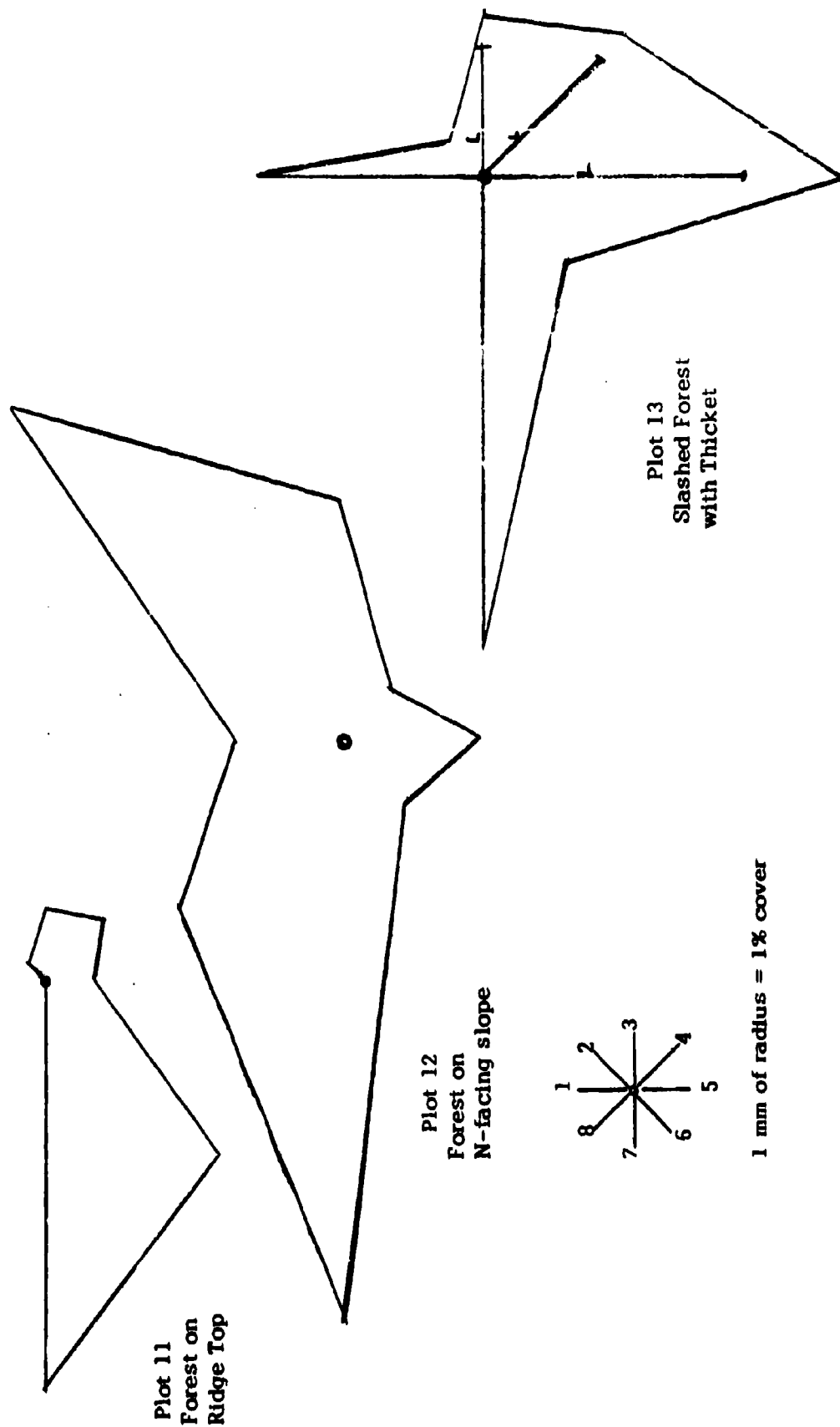


Figure 54. Distribution of cover in forest and slashed forest with thicket.

a conspicuous laurel thicket as understory. In Figure 55 three of the other four vegetation mapping types are similarly illustrated by diagrams of representative samples. Of these three only the slash type is highly variable with respect to the strata in which cover occurs. The others may be recognized immediately by their fundamental shape. For comparison, vegetation each of the mapping types is represented pictorially in Figures 56 to 61.

Variation between samples in per cent of cover at any given level is to be expected. Hence averages and ranges of variability are of interest. Figures 62 to 67 depict for each vegetation mapping type average cover per cents by height classes, together with the total number of kinds of structural elements which contribute to that cover. Again, there is a generalized characteristic profile for each of the types, although slash looks somewhat similar to forest with thicket. Actually in the field, sites of slash would rarely if ever be mistaken for sites of forest with thicket. Slash has lower total cover percentages and varies from place to place. Its density in height class five is due more to a weedy mixture of numerous kinds of plants, many of them woody seedlings, than to the comparatively uniform tangle of the laurel thicket.

Cover variation among samples by height classes is shown for old field, forest, forest with thicket, and slash mapping types in Figures 68 to 71. Here the ranges in cover (upon which the averages of the previous figures are based) may be compared and are seen to

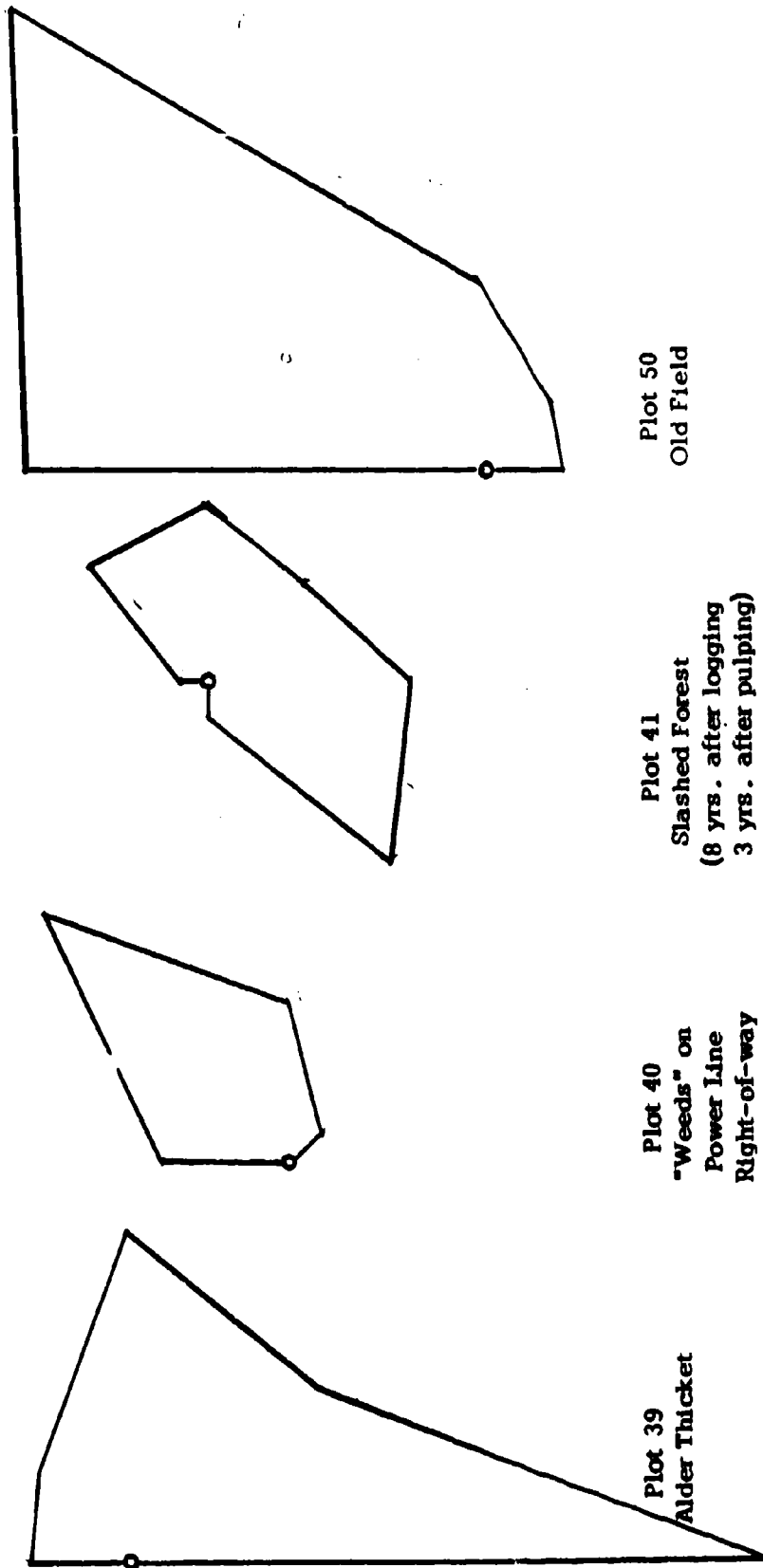


Figure 55. Distribution of cover in thicket, old field, and slashed forest.

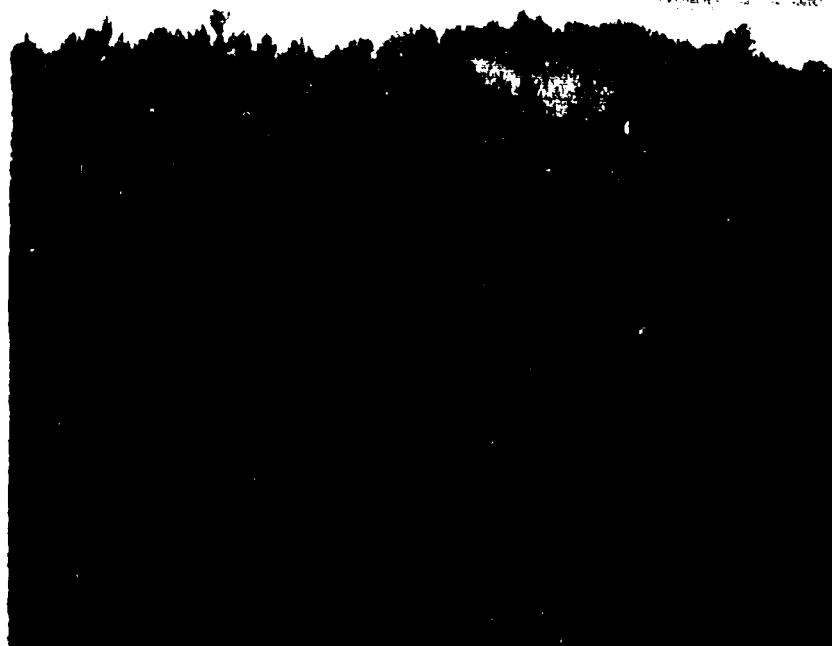


Figure 56. Old field vegetation being invaded by pine forest. Pole-sized white pines in background are probably younger than apple tree in center.



Figure 57. Thicket of relatively even-aged pine saplings.
Note persistence of leafless branches in lower height classes.



Figure 58. Park-woodland of scattered large oaks above an abundant herbaceous ground cover layer.

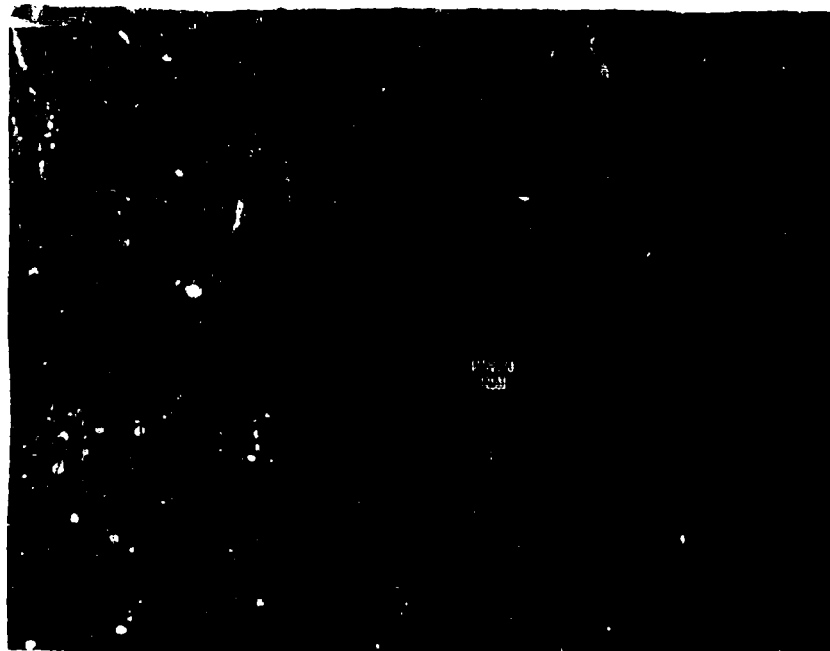


Figure 59. Forest with thicket. Pliant *Rhododendron* stems support 124 per cent cover in height classes five and six. Tree at left is a large hemlock also having evergreen leaves.



Figure 60. Oak forest with reproduction evident in all height classes but with no thicket. Herbaceous ground cover of 34 per cent is interspersed with 2 inch thick leaf litter.

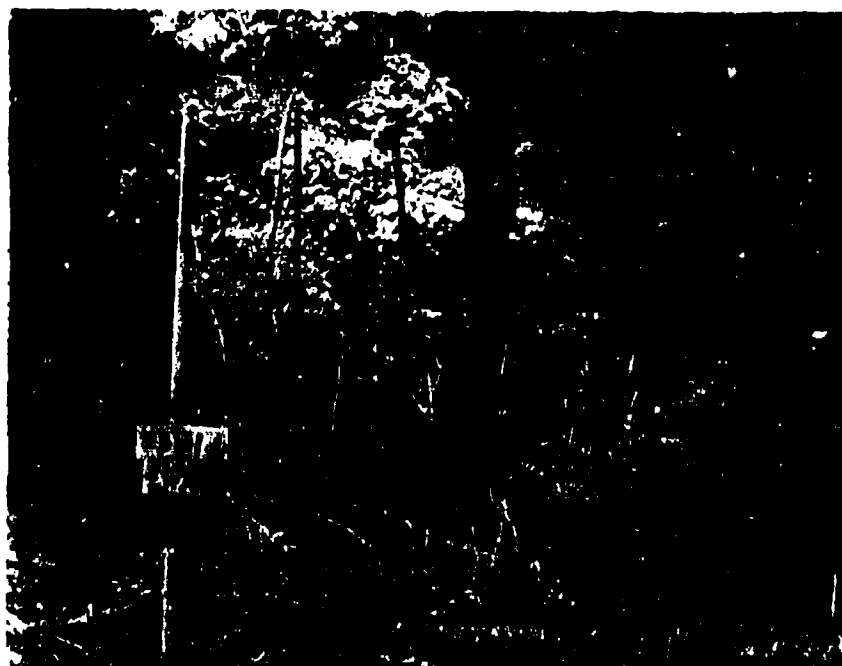


Figure 61. Slash vegetation with abundant down limbs and tops.

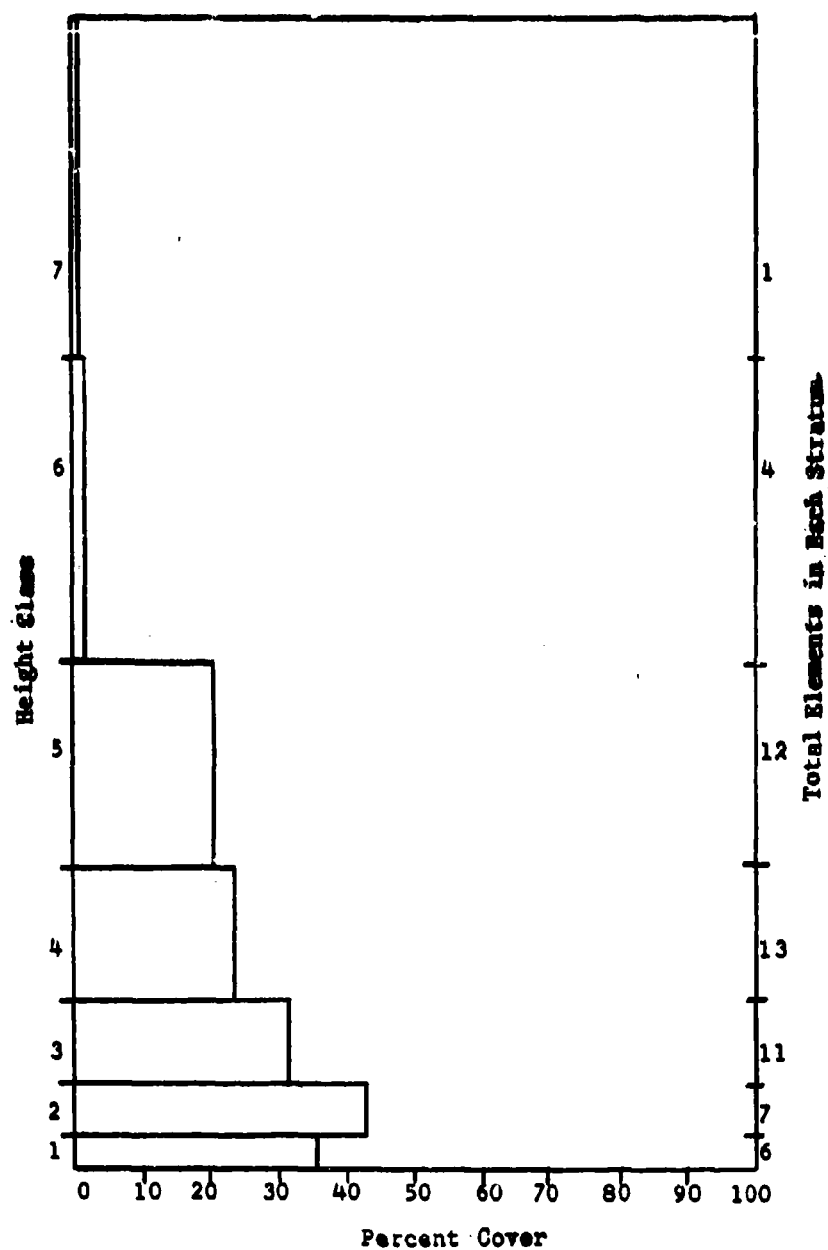


Figure 62. Average cover stratification in thirteen samples of old field vegetation.

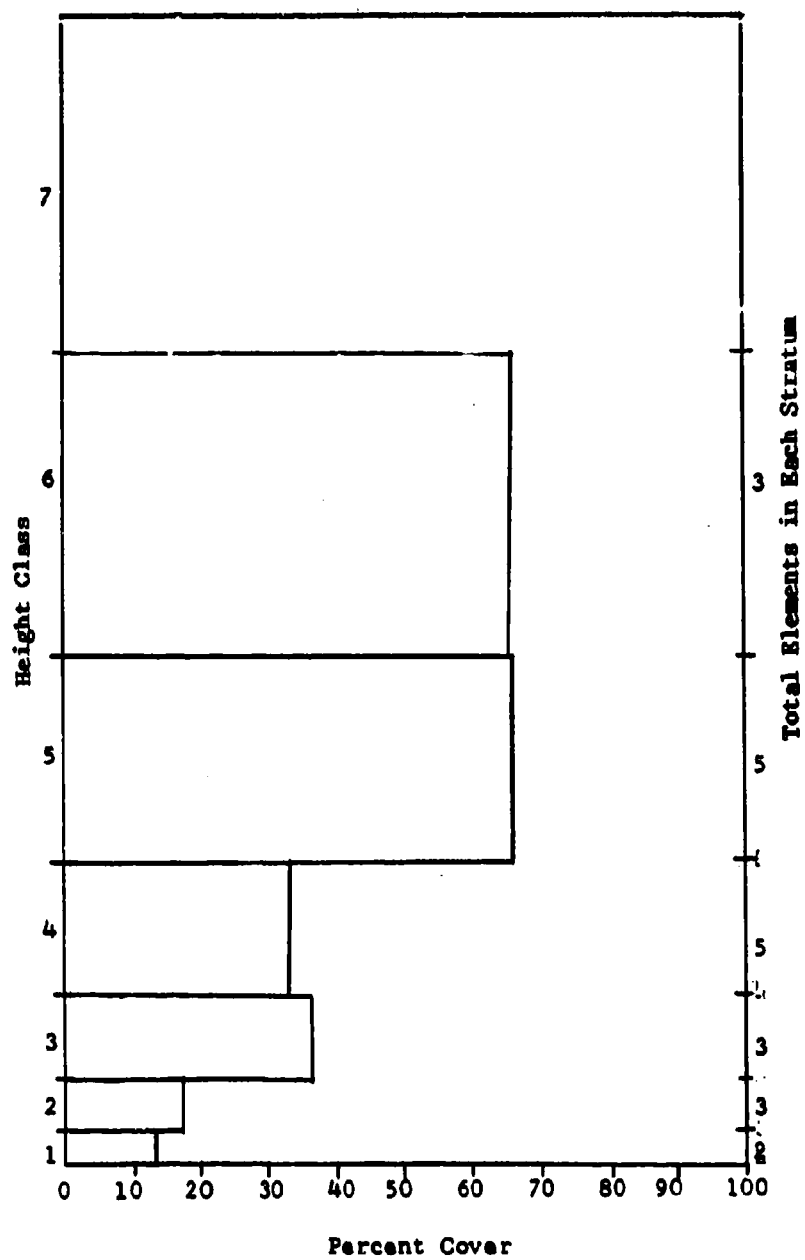


Figure 63. Average cover stratification in three samples of thicket.

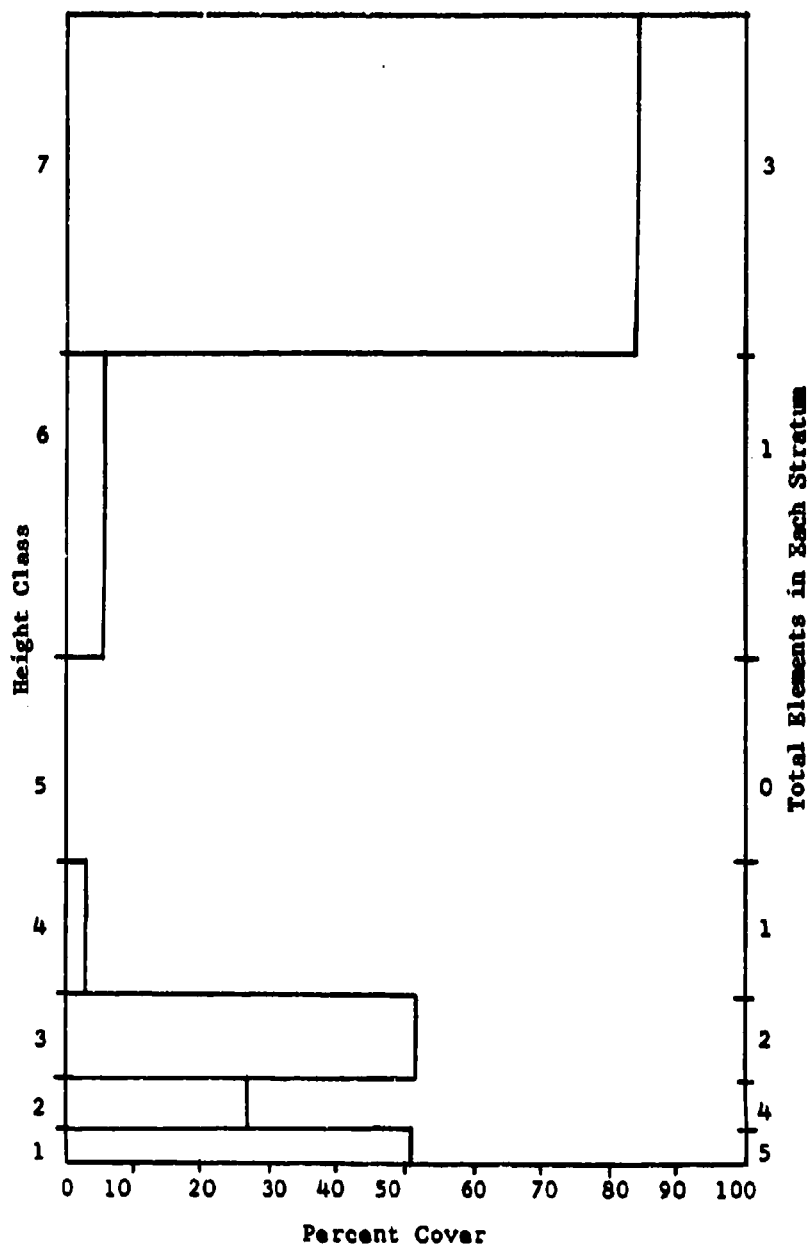


Figure 64. Average cover stratification in two samples of park woodland.

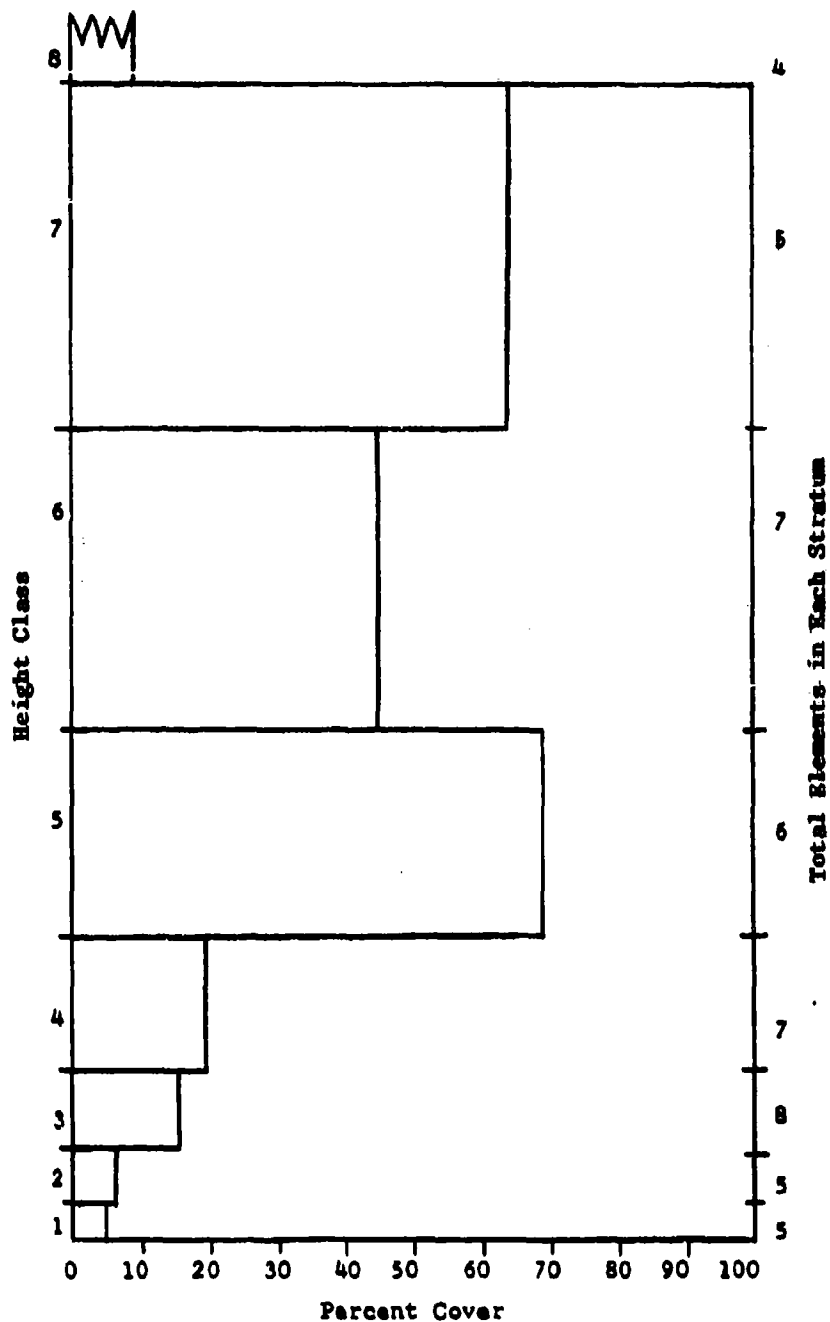


Figure 65. Average cover stratification in seven samples of forest with thicket.

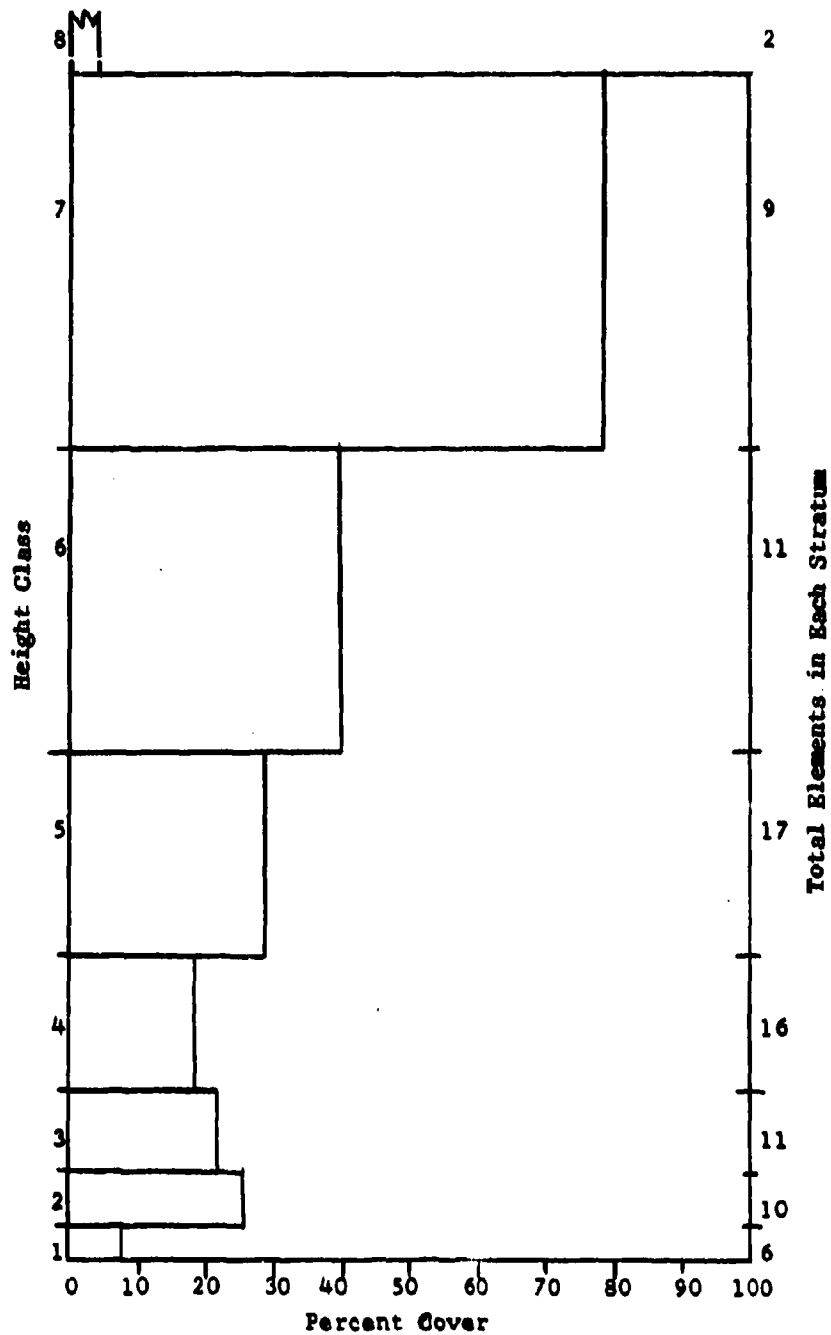


Figure 66. Average cover stratification in twenty-five forest samples.

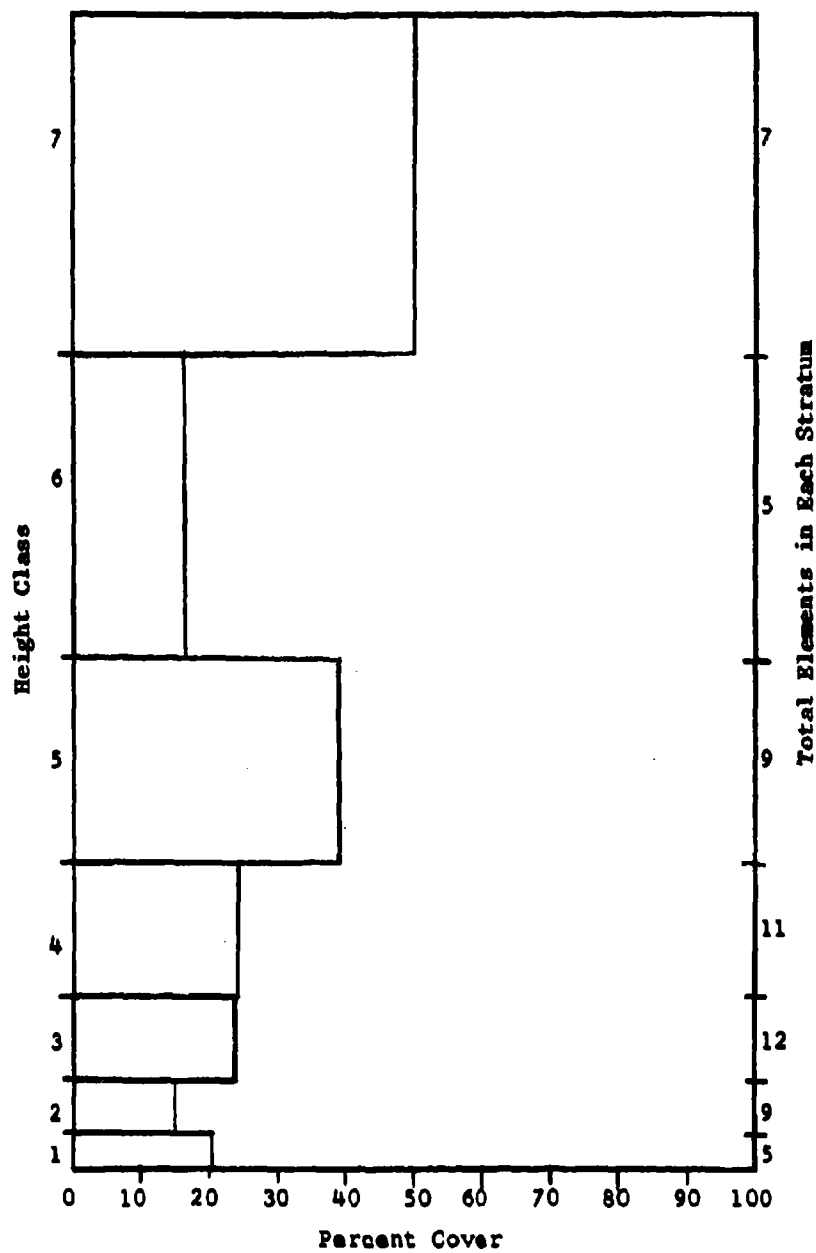


Figure 67. Average cover stratification in nine samples of forest slash.

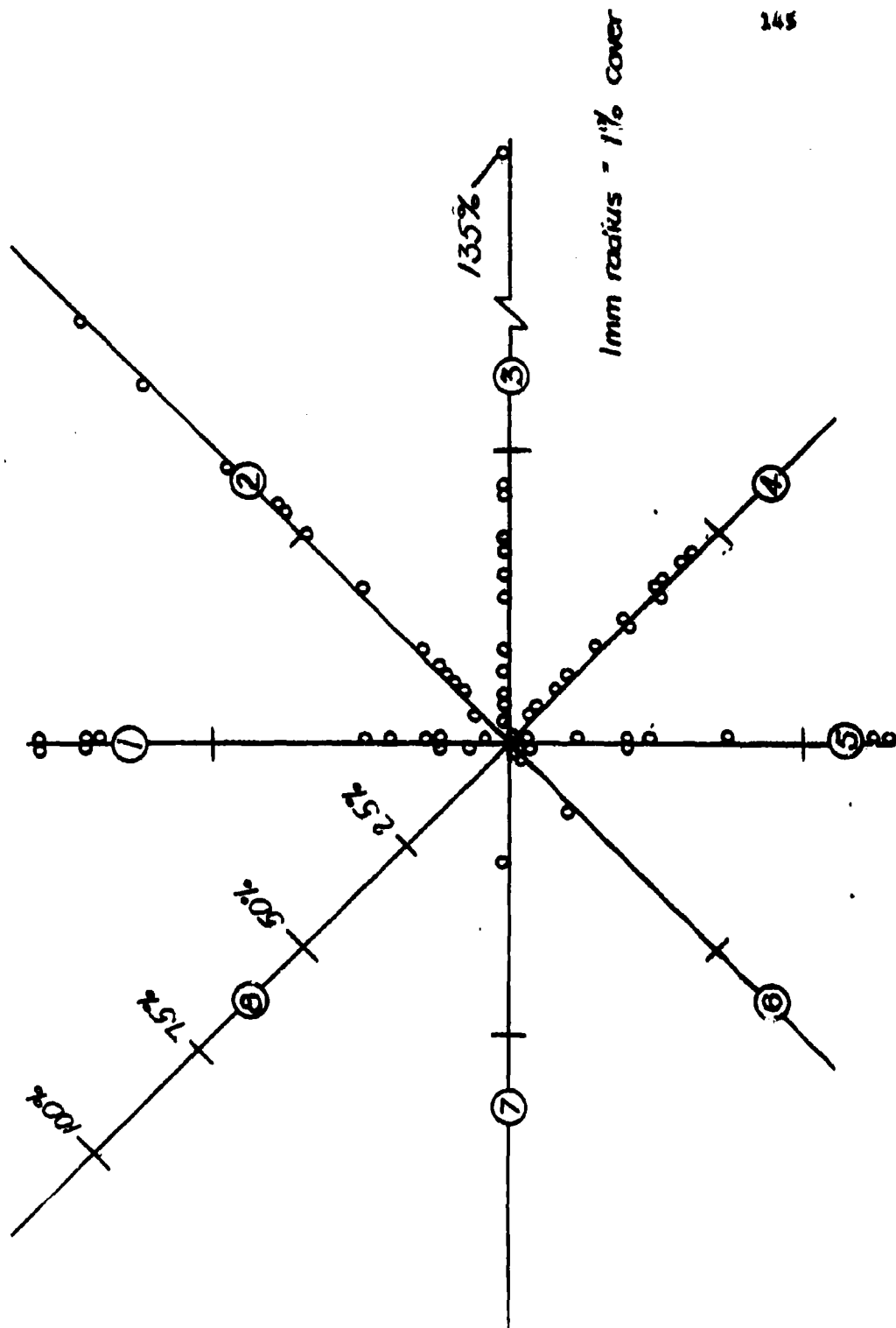


Figure 68. Range of cover by height classes in old field vegetation.

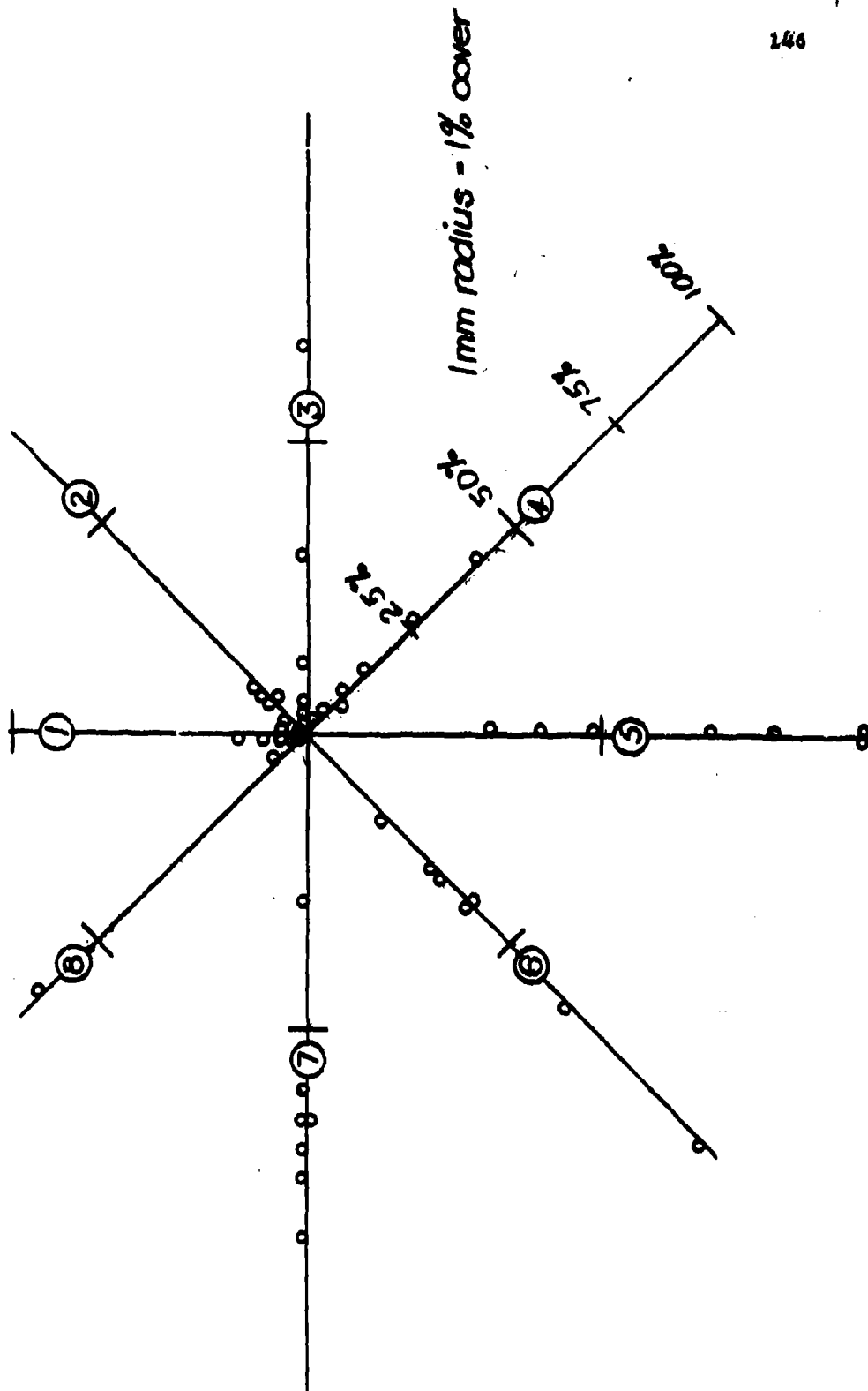


Figure 69. Range of cover by height classes in forest with thicket.

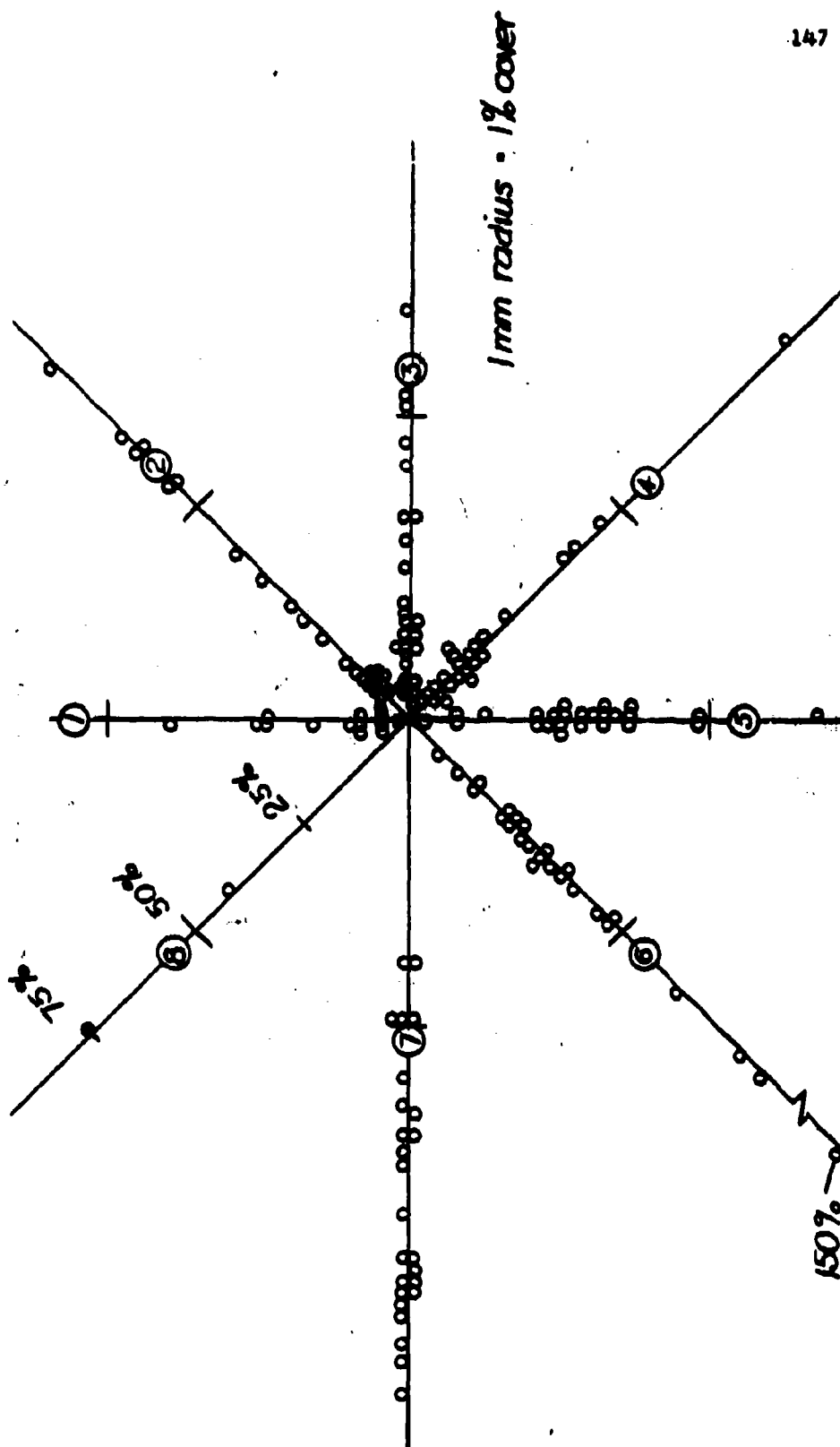


Figure 70. Range of cover by height classes in forest.

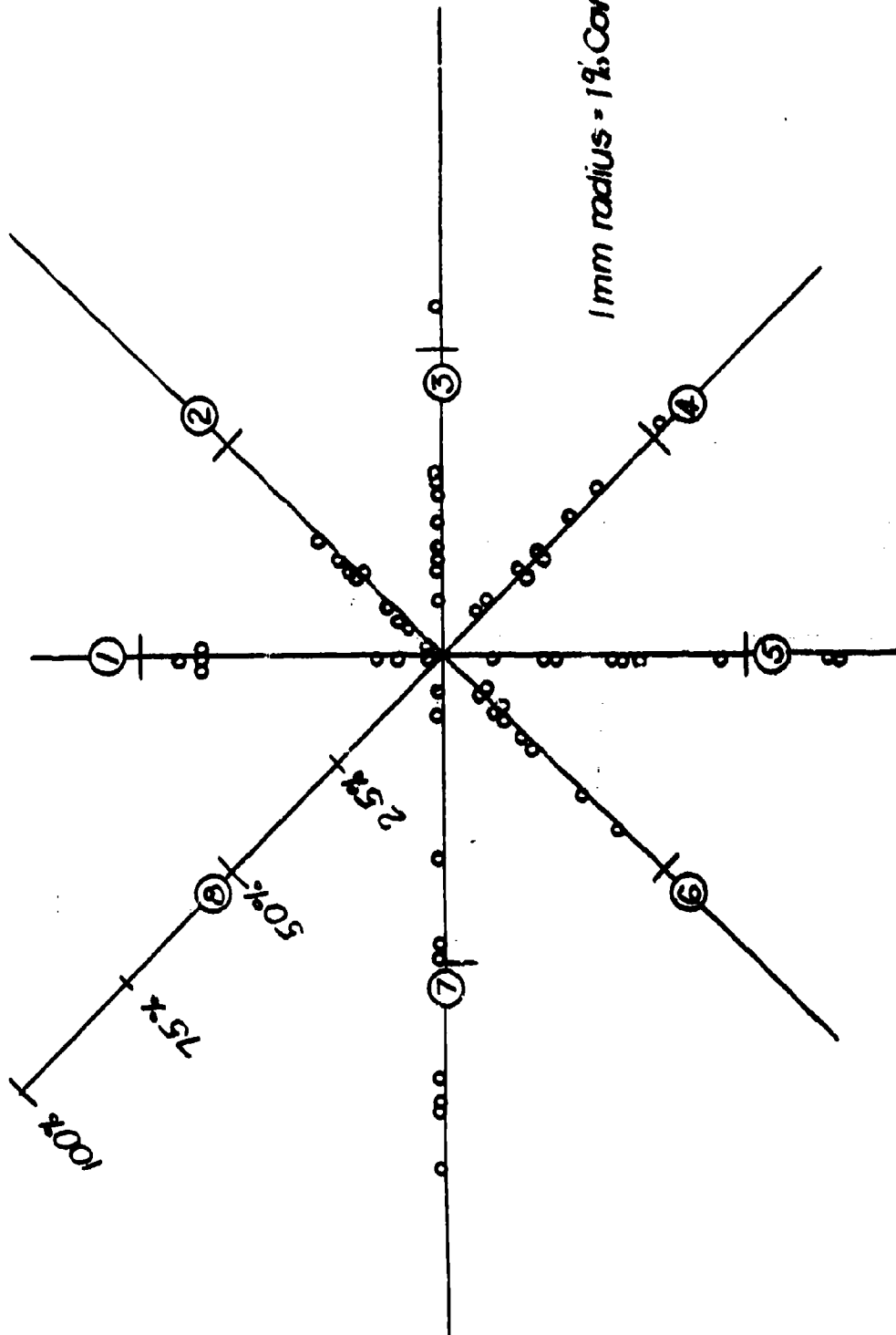


Figure 71. Range of cover by height classes in nine samples of forest slash.

have wide latitude. In fact, with such latitude it is obvious that adequacy of number of samples quickly becomes a relevant question.

It was shown earlier that the number of structural elements per sample ranges from 5 to 30 with a median at 14. In Figure 49, page 122, it may be seen that the median number of elements in the samples from different mapping types also differs. There is overlap in the ranges, with forest samples being most variable followed closely by old field. Slash has only half the variability of forest but averages nearly 50 per cent more elements per sample. A further look at distributions of structural elements is of interest.

Numbers of elements per stratum in the different kinds of mapping units is summarized in the following table:

		Old Field	Thicket	Park- Woodland	Forest with Thicket	Forest	Slash
Number of samples		13	3	2	7	25	9
		Numbers of elements					
Height classes	8	--	--	--	4	2	--
	7	1	--	3	5	9	7
	6	4	3	1	7	11	5
	5	12	5	--	6	17	9
	4	13	5	1	7	16	11
	3	11	3	2	8	11	12
	2	7	3	4	5	10	9
	1	6	2	5	5	6	5
Total Elements		54	21	16	47	82	58

Table I. Distribution of Structural Elements by Strata Within Mapping Units.

In each vegetation type except park-woodland the frequency tends to be greatest in the intermediate class heights. Forest includes the greatest total number of elements and park-woodland the least. Plots in slash may have more kinds of elements present per sample, but the total number of kinds present in all of its samples is more like the intermediate total numbers present in old field and forest with thicket types. Altogether, not counting litter materials, 128 structural elements were present in the samples indicated above and 45 of these occurred only once. None was universally present, and only forest included more than 50 per cent of the total number of kinds.

Comparability of data becomes a pertinent question when considering these results in detail. It is likely that the plot sizes were all of minimal area or larger with respect to the dominant plants, but samples were not of the same size (or number) in the different types. For example, the diameters of thirteen samples of old field type ranged from 10 to 50 and averaged 27 feet. In seven samples of forest with thicket the range was 30 to 100 and the average was 71 feet. The 25 samples of forests which were used for detailed study were of the 100 foot diameter size and were therefore comparable in area at least. In spite of such differences the pattern of total numbers of elements present in the types is perhaps instructive. The numbers of elements involved are reasonably large and can be treated in some ways as if they were species. In Figure 72 "structural element-area" curves for four of the mapping

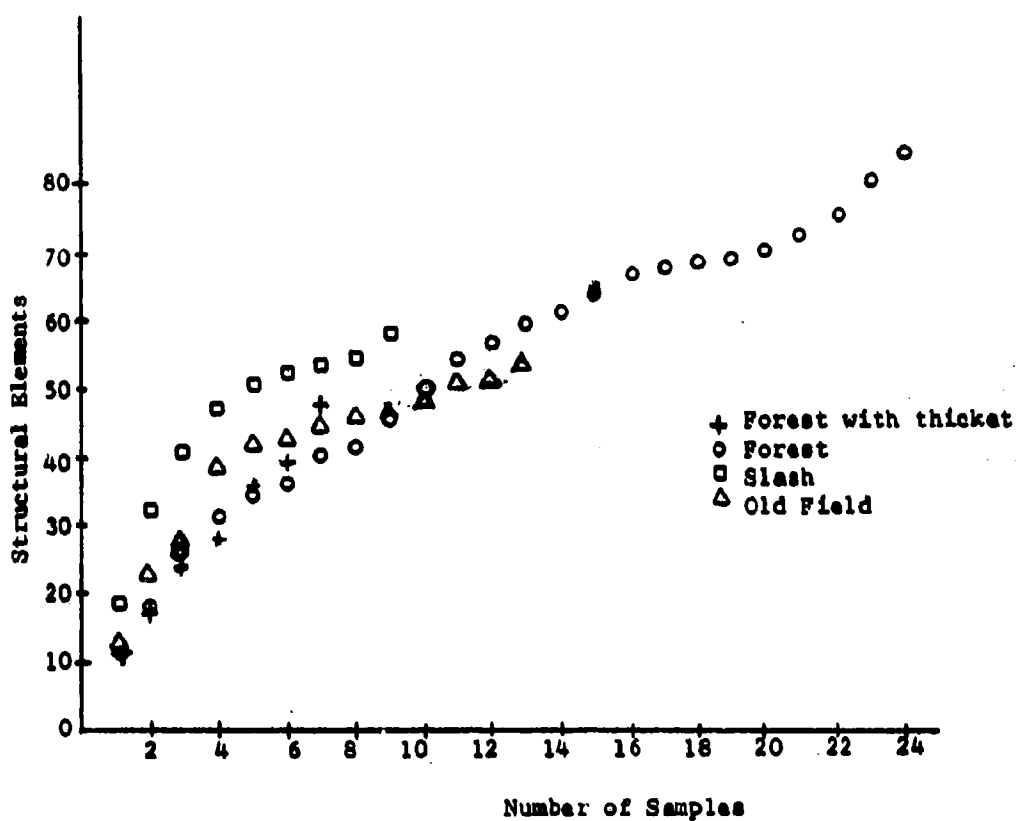


Figure 72. Structural element-area curves of four mapping types.

types are presented. From these it can be seen that slash and old field rather quickly within the number of samples available tend toward a "plateau" relationship. Forest with thicket, however, exhibits only slightly less than a linear relationship, and one could wish for at least another dozen samples of it. The forest curve shows a general trend toward flattening out but not without wavering.

Actually, there is an additional and perhaps subjective variable in these curves. They have been plotted as the field data was gathered chronologically, and the time elapsed was a matter of six to seven weeks. Forest samples were taken throughout the period and could therefore reflect seasonal changes in the lower and herbaceous vegetation as it continued to develop. Forest samples were also taken in particular areas. A number of early plots were taken on the south face and ridge top of Conner Mountain followed by a series down the Toccoa River valley past Gaddistown. A third and last series was mixed and included the moist white pine-hemlock forests intermixed with upper slope types. These three series are known to include different floristic and frequency lists of plants, and it seems likely that a very long series of perhaps 40 to 50 samples located randomly and without respect to types would be required to include the variability of forest that exists.

Figures 73 and 74 show element-area curves within different height classes for the forest and old field series. Again chronology is involved but is of probable significance only in the forest series.

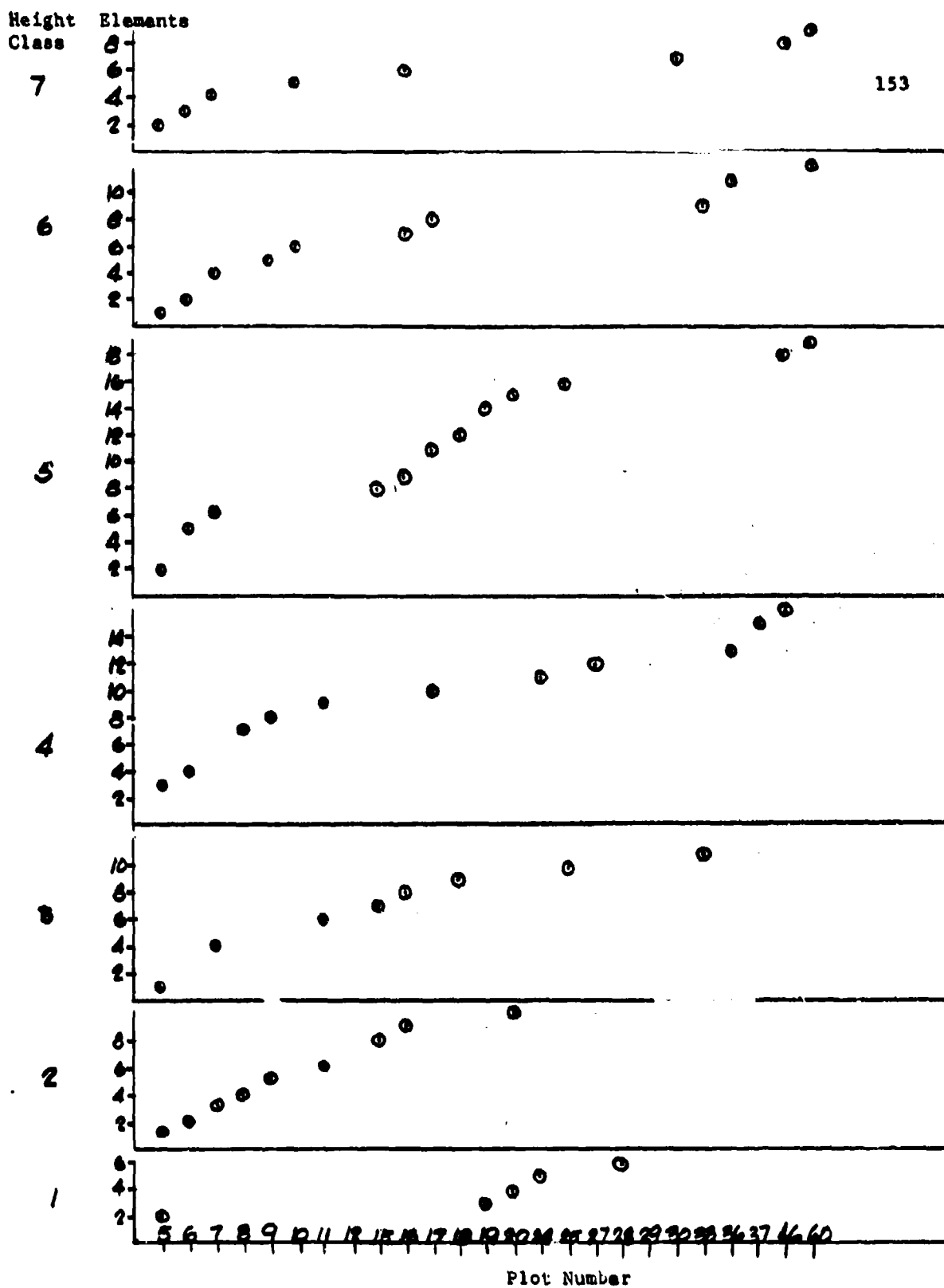


Figure 73. Element-area curves by height class in twenty-five forest samples.

Height Elements
Class

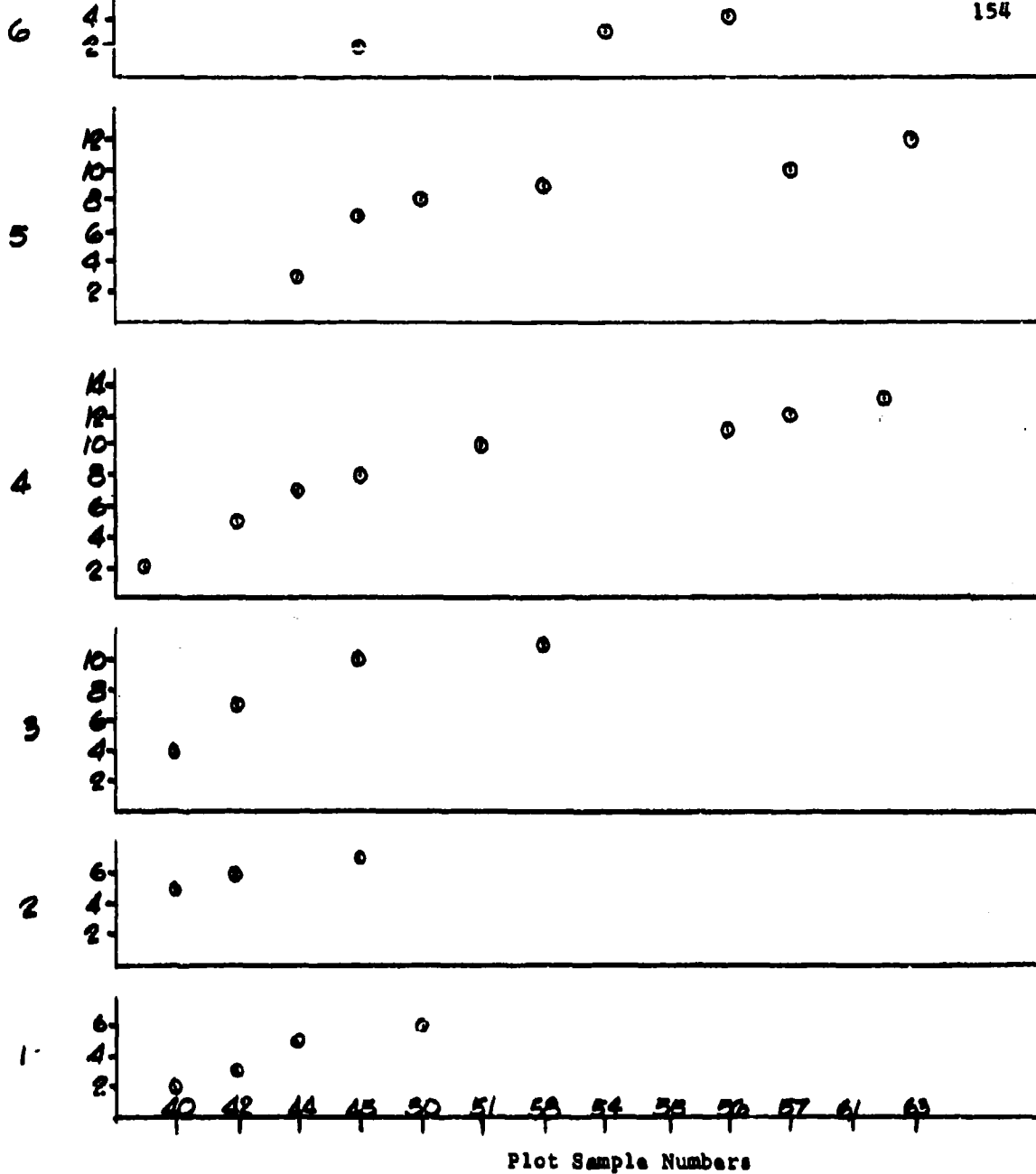


Figure 74. Element-area curves by height classes in field samples.

(All of the old field plots were taken in mid-summer within a period of two weeks.) In each series the dominant strata tend toward plateau relationship rather early but the accessories vary rather widely.

Importance as well as frequency of elements varies widely. In all of the twenty-five forest plots only one element was universally present (and in terms of cover it was exceedingly important). At the other extreme, forty elements were present only once in all twenty-five samples and their combined cover percentage is very low. Figure 75 shows, by Raunkiaerian type of grouping, the frequency distribution of elements in the forest samples along with the cover which they produce.

Although structural elements have much in common with species categories, in some respects they differ importantly. A certain species, as for example American holly, because of spines on its leaves is specifically represented and emphasized in every height class in which it occurs. On the other hand, floras can vary widely without differing in structural symbolization, and perhaps for military purposes this is unimportant. It ignores, however, the predictive and association qualities and therefore the indicator potential inherent in species recognition.

F. Problems and Recommendations

An adequate ratio of stems to crowns in the construction of the diagrams is likely to remain a troublesome item. Figure 76 shows how the present diagram system generally tends to underrepresent stem frequency especially in lower height classes.

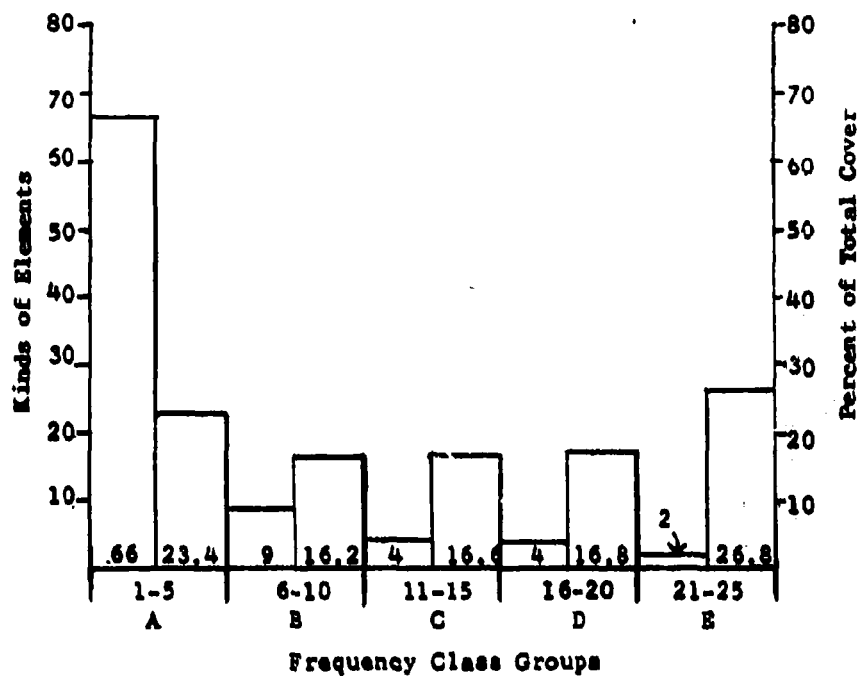


Figure 75. Presence distribution of elements in twenty-five forest samples in comparison with the cover they produce.

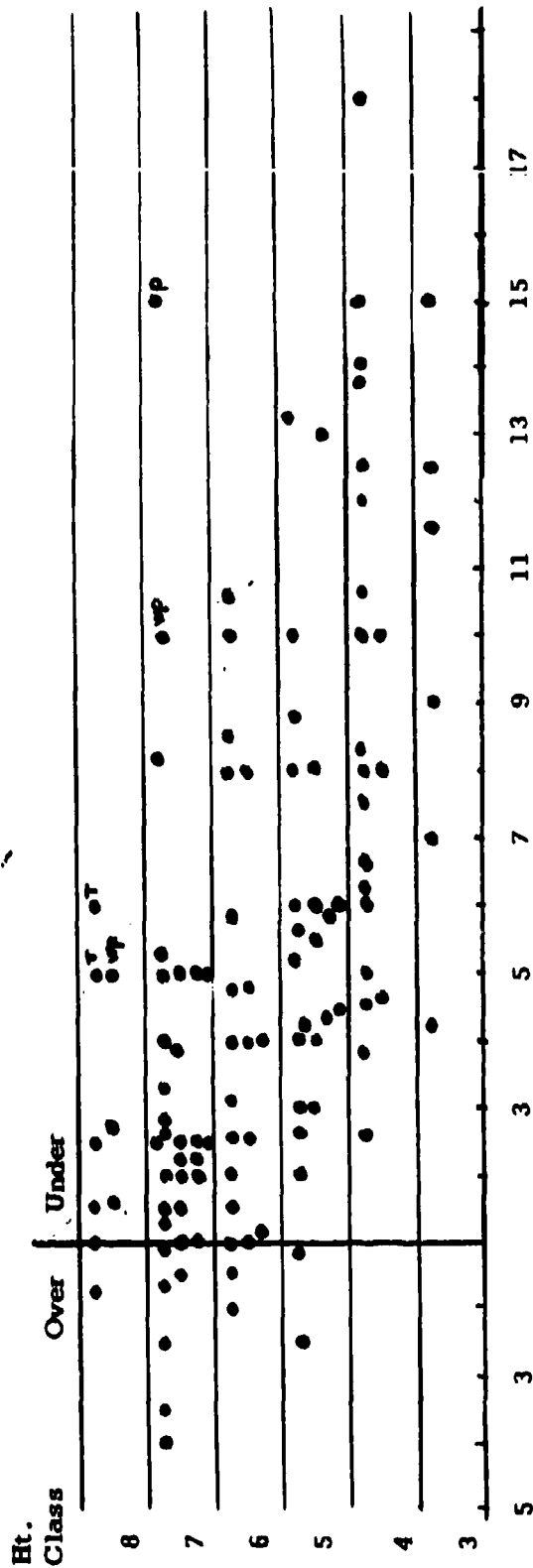


Figure 76

DIAGRAM REPRESENTATION OF STEM FREQUENCY

Definitive determination of individual crown shape among trees composing the overstory is difficult and sometimes nearly impossible in samples having high cover per cents in height class six or seven.

Better diagrammatic representation of mosses might be achieved by lumping them into a single separate symbol. We have used the low herb symbol with appropriate leaf designation (smallest size), which fails to distinguish a sometimes important community on rocks, logs, or ledges, from other small-leaved herbaceous plants (as Sedum or Oxalis).

In many areas, especially in the slash type of vegetation, there are more than negligible amounts of down branches and limbs in fresh to advanced decay condition. These were distinguished from purely prostrate stems (which were considered microgeometric figures) and recorded as woody decumbents by appropriate height class and commonest stem diameter. No leaf symbols in these generally set them clearly apart in the diagrams.

How to extrapolate from a given sample to the adjacent vegetation is a major problem. Development of some key significance of a few recognisable symbols for use with good photographs seems the present best hope. There is little or no problem in mapping the vegetation of the sample areas proper (at almost any class height) with the detail of data now obtained.

Only limited stem frequency and essentially no crown mapping data was obtained in the Ranger training area. More information is needed before the distribution of rare elements, especially those tending to clump, can be evaluated.

The adding of the cross hatch grid to the diagram symbols seems an inordinate waste of time and energy. Having shown size, texture, and shape, unless otherwise specified, it might well be assumed that the leaves were present on the specimen in living condition when the observation was made.

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